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THE PASSING OF THE TELEOLOGICAL EXPLANATION.*

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The term "Teleological" has had such an array of meanings in scientific and philosophic writings that unless the content intended in this particular discussion is made very clear we should become hopelessly entangled. Included, however, in every particular meaning that the word has had is the idea of an end,—a goal that is good, or beautiful, or useful, for the purpose of which the thing exists or the process is carried on. In philosophy at the one extreme this idea has been applied to explain the universe; in biology at the other it has been advocated for the origin of the most minute organ.

I. THE INFLUENCE OF OUR ENVIRONMENT.

The attempt to interpret natural phenomena is apparently as instinctive to man as the effort for self-preservation or the development of a social organization. Primitive man in his struggle for existence is brought into the most intimate contact with nature's forces. His attention is arrested by the light and the darkness, the rain, the thunder and lightning, the heavenly bodies, the flood, and the drought. He apprehends his surroundings piece by piece. He knows little of relations and nothing of processes. The only source of power with which he is familiar is his own will. Hence he ascribes to every natural object a will; and every natural process becomes the result of some one's willing. In other words, his several surroundings become personified. He satisfies *his* "satiable curiosity" by peopling his world with unseen spirits. Some are benevolent and beneficent, more are malevolent and maleficent. The animus of all must ever have his consideration. His life is dominated by feeling—his explanations by fancy.

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A more advanced stage of development is indicated by an insight into some of the simpler relations of objects and phenomena. However vague and untruthful they may be, the perceptions of organizations of objects and forces in place of kaleidoscopic unities lifts him into a new realm. A collection of wheels and shafts and cylinders is not an engine until each has been put into its proper relation to all the others. In so far as this stage of man perceives and attempts to relate his contiguous objects and forces, he constructs out of his "surroundings" an environment. The number of petty spirits of whom he must be mindful becomes transformed into an hierarchy of generalized beings whose control extends over groups of phenomena. To be sure, his environment is completely personified, and usually he feels confident that it is all for his special benefit.

Civilization brings with it merely an increase in the proportion of natural explanations for natural phenomena. The rain is related to the clouds and the winds, the torrential storms and hurricanes to particular kinds of clouds and certain seasons. Abundant harvests are the results of favorable conditions of soil, moisture, and temperature. But even during the period of Greek supremacy these phenomena were all in larger or smaller groups personified. "The enlightened Athenian," says Fiske, "addressed the sky as a person and prayed to it to rain upon his garden. And for calling the moon a mass of dead matter Anaxagoras came near losing his life. The moon was the horned huntress, Artemis, coursing through the upper ether, or bathing in the clear lake; or it was Aphrodite protectress of lovers born of the sea-foam in the East near Cypress. The clouds were no bodies of vaporized water; they were the cows with swelling udders driven to the milking by Hermes, the summer wind."

In spite of all this there were some among the Greeks who had developed remarkable insight into plant and animal life, but even these described the fanciful monsters of their legends and attempted to classify them along with the organisms they knew.

If now we compare with these the insight into natural phenomena of the average American, we feel that great advances have been made—especially during the wonderful century of invention just past. The increased facilities for travel and communication have contributed much. The discovery of better methods for scientific investigation have yielded results impossible under the older discipline of dogma and deduction. The public schools have brought these conclusoins to all classes of

people. The rapid increase of newspaper and periodical reading has had a worthy influence. Yet how few there are among us who can carry the idea of natural law into all of their thinking and who are willing to accept the consequences of a natural explanation for natural phenomena. The clairvoyant and the charlatan still thrive in our midst. The healer who cures by the touch of his hand, the patent medicine fakir, the astrologic weather prophet, and the promoters of something for nothing not only are with us, but enjoy the confidence and respect of a majority of us. Most of us still excuse our incompetence by an appeal to luck, and many of us still plant and reap by the signs in the almanac. This is *our* environment. It should be easy then to see how causes and uses, effects and ends may not infrequently change places in our thinking.

II. The Influence of Philosophy.

Teleology has played the master rôle in practically all philosophic systems from Plato to our own times. Philosophers generally and a majority of biologists believe that it always will. The effects of this point of view on scientific investigation have been far reaching. I wish to take up here only its relation to biological ideas.

The greatest legacy left to the natural sciences by the Greeks was the desire of their greatest philosophers to substitute natural explanations for mythological ones. That this is not a universal trait is abundantly evidenced by the people of the Orient. Combining as the Greeks did, a wide range of ideas with great freedom of thought, they launched boldly and began with theories of the universe. They were not impeded by researches upon the natural objects themselves, and they rarely paused to put their theories to the test. But by their remarkable powers of deduction approached the truth as by inspiration. Plato was among the first to ascribe the orderliness of the universe to an inherent purpose.

Aristotle, the first great naturalist had a remarkable first hand knowledge of plants and animals. He not only understood the distinctions between the organic and inorganic realms, but the essential differences between plants and animals. He appreciated the physiological division of labor among the bodily organs. He had some correct notions of the forces of heredity and parental prepotency. He recognized the unity of type in certain orders of animals, and conceived the idea of a gradual evolution of or-

ganic forms. He preached induction for the interpretation of nature, but he largely practiced deduction. Here we are mainly concerned with his teleological idea of an untimate final cause. This he conceived to be an innate everpresent something which directs all progress by the desire of all to approach its ideals,—an approach which he thought to be largely realized.

The early church fathers, Augustine and Aquinas, were greatly influenced by Aristotle and accepted his evolutionary conceptions. Through the Middle Ages these Aristotelian notions lived side by side with the church doctrine that all events are caused by God's will looking toward a future state of perfection. It was not until the sixteenth century that the doctrine of "Special Creation," asserted by Suarez, led the teachers of the church away from the philosophical standards of the early theologians. The scientific renaissance of the sixteenth century influenced and combined these theories into the doctrine that the great mechanism of nature had its origin in the Deity. Its operations go forward for the sake of the good, the beautiful, and the true things that result. That all this is not only for our present benefit but for our ultimate perfection. Immanuel Kant is largely responsible for the setting aside of this particular form of teleology by philosophy. Writing during the latter half of the eighteenth century he attempted to reconcile the mechanical theories of Newton with the teleological conceptions of his predecessors. He recognized the possibility of a mechanical explanation for the inorganic world, but his instinct for scientific evidence prevented him from giving credence to such a principle in the domain of life.

Concerning the limits of knowledge he says: "It is quite certain that we cannot become sufficiently acquainted with organized creatures and their hidden potentialities by aid of purely mechanical natural principles, much less can we explain them; and this is so certain that we may boldly assert that it is absurd for man even to conceive such an idea, or to hope that a Newton may one day arise even to make the production of a blade of grass comprehensible, according to natural laws ordained by no intention; such an insight we must absolutely deny to man."

Haeckel observes that Darwin was Kant's Newton of the organic world, for in 1858 he offered an explanation of the origin and development of these very structures and relations.

This brings us to the period of evolutionary thought in which Lyell, Spencer, Darwin, and Huxley laid the foundations of a

new method of attack upon scientific problems. Lyell offered a new interpretation of the phenomena of geology. Instead of a geologic past founded on catastrophes and cataclysms, he urged the fact that the structure of the rocks and the fossil records they contain can only be properly interpreted in the light of the present day natural processes. In other words, he advocated the idea of the gradual evolution of the earth's features through a vast period of time under conditions and forces now operative. Darwin was influenced by Lyell's writings, but more especially by his own extensive observations of nature during the five-year voyage of the "Beagle." He proposed to account for "the ordliness" of the plant and animal kingdoms by a somewhat similar genetic theory. The elements of this theory are: the variability of species, the fecundity of organisms, the struggle for existence, heredity, and the selection and survival of the fittest. So clearly did he state his theory and so thoroughly had he gone over the ground before he attempted publication that he at once enlisted the sympathies of many great biologists. These and their students have broadened the scope and modified the details until today the whole field of biological investigation is dominated by his genius. More than this, the genetic point of view has been developed in all phases of science with results as illuminating as those of biology.

Evolution had another consequence of which we must speak. It accentuated the already growing tendency of science to separate from philosophy and concern itself with the more immediate relations of nature, leaving to philosophy the problems of ultimate ends and causes. In speaking of philosophers Paulsen makes clear his attitude toward the science which neglects these ultimate problems. "There will always be men" he says "who, like old Christian Wolff are ready to expose their thoughts on God, the world, and the soul of man, as well as of all things in general, to the malice of the prudent, to the reprimands of the wiseacres, to the shrugs of the connoisseurs, and to the laughter of the multitude. Perhaps they may find consolation in the fact that they are not entirely useless to the community. If they accomplish nothing else, they do one thing at least—they call attention to the ultimate aim of all investigation, which is to orient the human mind in the world of which it is a part. The sciences are apt to lose sight of this aim led from fact to fact, they finally forget their original purpose. The reverse happens to them of what befell the son of Kish, who set out to

seek his father's asses and found a kingdom. Science which set out to seek a theory of the universe, is at last content and happy to find earthworms, and dissect them. And whenever like Faust, it begins to feel that there is something wrong with its critical endeavors, it straightway consoles itself with the general phrases: 'Nothing is too insignificant for the scientist'; or 'We are not yet ready for generalization.'"

Whatever truth there may be in this statement, there has been an occasional biologist who has tried to give back to philosophy the results of his experience with natural phenomena. The controversy between vitalism and mechanism may serve as a present day illustration. On the one side are the biologists who feel the inadequacy of the laws of physics and chemistry for the complete explanation of the structures and processes of organisms, and on the other are the advocates of the notion that while there is much that is inexplicable today there will come a time when this will be possible,—science is very young. The former find satisfaction in teleology; the latter believe that an appeal to teleology is a confession of weariness and they find no place for it in their conception of nature.

I have traced these points of view in philosophical teleology thus briefly because they have tremendously influenced the attitude of students of nature toward their materials, whether consciously or unconsciously. In all but the last of these philosophical systems we see that all things are for a purpose, all deal with ends as real explanations, all prescribe a final cause, and their inquiries deal with the relations of things to these final causes.

Having these philosophic influences in mind, and the difficulties of the application of scientific methods to the interpretation of familiar natural phenomena which come as a result of our environment, let us turn to some particular explanations of every-day science, which I had in mind when I proposed the topic of this discussion.

III. Some Illustrations.

Let me illustrate the teleological type first of all by an example that has recurred many times in my experience. Many plants of deserts and arid regions have spines and thorns. The question is asked "Why are these thorns present?" The answer comes "They are there for the purpose of protecting the plant from herbivorous animals." How did they arise? The natural

selectionist answers glibly "They have arisen through selection and survival." That is, the desert plants which varied in the direction of spines survived, the others perished. This overlooks the fact that when the plants are young and most in need of protection the spines in many cases also are tender; that the mass of vegetation in the desert is vastly greater than the amount needed for animal food; and that many of the spinose plants are eaten by small animals in spite of their armor. This notion of selection comes perhaps from observations in pastures where the thistles and hawthorns have been rejected for the grasses. It seems perfectly fair to ask how long it would take to develop spines on just one other of our common pasture plants if we made the danger of being eaten great enough. Few would care to undertake this problem experimentally. But certain plastic forms have been subjected to experiment with reference to the origin of spines. The best experimental results have been obtained by subjecting the plants to extreme drought and extreme insolation. Furthermore, in a good many forms it is possible to reduce the spines or thorns by growing them under moist conditions, Here then we have an explanation for which there is some direct evidence. It relates the particular organ to environmental factors, which is the essence of a scientific explanation. It is possible that selection in the desert may have been a factor in augmenting the spines, but it is pure speculation at best. Certainly the use or advantage of the spine is far removed from the cause. Teleology leads us far astray in this case.

Physics and Chemistry had been largely relieved of their teleological burdens before our day and I can now recall only two examples presented to me in my school days. Both relate to water. The first is that water is the commonest liquid on the earth because it is the greatest solvent. The second is that water has its temperature of greatest density four centigrade degrees above the freezing point, because otherwise the streams and lakes would freeze solid in the winter time and destroy all aquatic life. Further, the deeper lakes would not thaw out in the summer time. Present day students of the earth's development would probably suggest a very different explanation for the presence of water in such large quantities, their answers depending upon their attitude toward the several hypotheses of the earth's origin. As to its point of greatest density water is not the only substance atypical of the law of expansion. But in both cases it is better for the elementary student to appreciate the advantages of these

physical properties of water than to speculate as to their causes.

Physical geography which until recently had little scientific organization might furnish a number of illustrations. One example familiar to all of us must suffice, viz., the wonderful harmony which exists between animals and plants in their use of atmospheric gases. Animals breathe in oxygen and give off carbon dioxide, while plants take up carbon dioxide and give off oxygen. Some go so far as to say that the equilibrium of these two gases is wholly due to this reciprocal relationship. It was frequently implied that the plants use the carbon dioxide to prevent its accumulation and give off oxygen for the purpose of supplying the animals with that useful gas,—indeed that this function alone would justify their existence. This view of the matter is still very common, for the majority of the pupils who come to my classes have been taught it somewhere in their previous science work.

The history of this venerable fallacy is interesting. It appears that physiologists as early as 1779 had discovered that respiration in plants is just the same as respiration in animals,—that in both oxygen is consumed and carbon dioxide liberated. They also knew that plants have in addition to respiration a process of carbohydrate synthesis which takes place in the green parts of plants in the presence of light, in which carbon dioxide is absorbed and oxygen released. Sixty years later (1837) Dutrochet, because this carbohydrate synthesis masks the effects of respiration in green plants in the day time, called it "diurnal respiration." What we call respiration, because its product is readily observed in the absence of light, he called "nocturnal respiration." This is the starting point of the confusion. Liebig misunderstood the gaseous exchanges in carbohydrate synthesis altogether, ridiculed the idea of "nocturnal respiration" and by the force of his authority undid all the careful researches of the preceding half century. It was not until Sachs made the correction that anyone who thought otherwise could get a hearing. That was about a half century ago. It was soon corrected in the advanced physiologies, later it disappeared from the elementary textbooks, and now it survives only in obselete physical geographies and the legends of the schoolroom. Verily the errors of authority retreat but slowly before the truth, and they make their last stand in the manuals for the elementary school. A great teacher has said "When knowledge is dead we bury it in books." He overlooked the successive disinterments that await it in the preparation of simplified textbooks.

The evolutionary writings of Lamarck teem with teleological illustrations. Many of them have never been seriously regarded by later writers, but occasionally they have been attributed to Darwin by critics whose best information is hearsay. Lamarck postulated two laws of nature: First, Organs increase in size and strength in proportion to their use. Disuse leads to degeneration. Second, Nature preserves everything she has caused the individual to acquire. This is teleology rampant. How it results in evolution may be shown by two examples.

1. Why snakes are without legs. Reptiles generally have four legs. Snakes have the habit of gliding over the ground and concealing themselves in the grass. Owing to their repeated efforts to elongate themselves in order to pass narrow spaces, their bodies became drawn out. Long legs would interfere and short ones would be useless. Since the reptilian plan of organization limits them to four legs, and since this number would be unserviceable, they have disappeared.

2. Why the giraffe has a long neck and long fore legs. The giraffe inhabits central Africa where the earth is dry and without herbage. It is obliged to feed on the foliage of trees and this leads to continual upward stretching. Continued through a long period of time, this results in the long neck and the long forelegs. One might well hesitate at this explanation after seeing the many photographs of giraffes in their native environment that have been published in recent magazines.

This type of teleology seems very crude to most of us, but when it is applied to less familiar subjects it may appear very plausible. The fishes in the underground streams of caves are blind. They gave up using their eyes because the darkness rendered them useless. Therefore the blind fishes of caves lost their eyesight through disuse. This is precisely the same kind of reasoning and it too is open to suspicion. Certainly it is only one of several possible explanations and until we have more data concerning the influence of their subterranean habitats it had better be held in abeyance.

Darwinism as I have said offered a new method of attacking scientific problems. It altered the point of view of the student of biology from one that was essentially static to one that is dynamic and genetic. It has probably done more to banish the teleological explanation from botany and zoölogy than all other theories. Nevertheless when natural selection is carried to the extreme it may develop its own form of teleology and become a stumbling block to scientific progress.

Take for example an illustration of the so-called "protective mimicry." The common large brown butterfly known as the Monarch is closely matched in color by a smaller butterfly, belonging to another family, generally known as the Viceroy. The relatives of the Viceroy are generally blue, with white and red markings. Because the Viceroy is brown, it is supposed to have developed its color as a protection. The Monarch is said to be distasteful to birds and the Viceroy escapes destruction because the birds mistake it for the Monarch. If it is true that the Monarch is distasteful to birds then there might be some advantage for the Viceroy to resemble it. No field observations exist to prove the theory, and there are so many "ifs" in the argument that at best it is highly speculative. Many groups of moths and butterflies are exceedingly variable, and forms with aberrant colorations are not infrequent. Further it has never been shown that this brown Viceroy is in the least degree more successful than its blue relatives.

The butterfly Kallima which when its wings are folded together bears great resemblance to a leaf, is another case held up to the admiration of the elementary student. While we may well remark upon the curious resemblance, we should be careful to state that there is no field evidence that this coloration is of advantage.

Another example given in several elementary textbooks shows a treehopper with brown legs and under-parts. The upper parts are developed into a tall thin green ridge. This insect is supposed to resemble a brown leaf-cutting ant carrying a small leaf on its back. On account of this resemblance the treehopper is said to gain protection. In the illustration, where the two are shown side by side, the artist has carefully drawn a leaf segment for the ant to carry which is exactly similar in outline to the treehopper's back. When one looks at the illustrations of these same ants in other books where mimicry is not discussed, one finds that the leaf segments are of all shapes and that they are mostly not held in this position down the middle of the back. This is stretching credulity to the breaking point. The lure of protective resemblance has developed the imagination of its devotees until they draw conclusions satisfactory to themselves from syllogisms in which both premises are hypothetical. In this last instance the premises are: the leaf-cutting ant is avoided by insectivorous animals; the treehopper more or less resembles an ant with its burden. The conclusion is that the treehop-

per is protected from insectivorous animals and on this account its form has been developed. How can we ever hope to develop correct methods of thought in our students with this kind of material? Perhaps one of the reasons that the scientific method does not carry over into other fields is because it does not carry throughout its own field.

We have here on the prairies a plant, the Rattlesnake Master (Eryngium) belonging to the carrot family—a group in which compound or finely divided net-veined leaves is the rule, and the flowers are borne in umbrella shaped clusters. Now the Rattlesnake Master has grasslike parallel veined leaves and the flower cluster is not umbrella shaped but an irregular group of floral heads. All the gross features suggest the grasses and yuccas. No one, I think, has offered this as a case of protective mimicry but it has all the elements necessary for that category. There may be some excuse for the teleology founded on a really known use. But how about the teleology in which even the use or advantage is imaginary.

The root hairs of plants have been cited as an adaption for the purpose of increasing the absorptive power of the root. This is a case which like the spines of plants has been subjected to experiment. It has been found that root hairs commonly do not develop in water and that they develop best in moist air. The teleologist says this is just what one would expect under a theory of use: there are none needed in a water medium, hence none develop; they are needed in moist air, hence they are forthcoming.

But they also develop in saturated soil and they do not develop in dry soils where they are needed most of all. So the card house falls! Root hairs respond in their development to various external stimuli. They are retarded in rapid root elongation. They are favored by conditions which slow down root growth. Their presence or absence is best interpreted in the light of these conditions.

Nature study naturally has formed the lower-most sieve for all sorts of *disjecta membra* of the natural sciences. Its books are full of these wonderful relations. Some say: "What of it? If they bring about a love for nature and an interest in natural phenomena, these errors can be corrected farther along in the schools. Furthermore the scientific attitude toward nature-study materials is just what we don't want. Studying nature as the scientist does is not nature-study! We want to develop an aesthetic and ethical point of view in our children, not the sci-

entific." In the light of results obtained by grade pupils working with familiar plants and animals under strictly scientific conditions, one wonders how it could have been improved by assuming more and guessing the rest.

Let me illustrate the one kind of nature-study by a story from a rather recent book, written by a zoölogist of undoubted standing. *Why cattle chew their cud.* Although I must shorten the explanation greatly, essentially it is as follows. Cattle lived originally where there were wolves. The cattle were much disturbed by the wolves. The cattle learned to go to pastures, feed quickly, and then return to their safe retreats where the wolves could not follow. This led to the habit of partial regurgitation and post-prandial chewing, finally to structural modification for this very purpose. Here is an explanation at once simple and satisfying!—if only there were some evidence to show that there is a grain of truth in it. In this kind of nature-study the child has the whole environment explained, and the book illustrations are so beautiful that he has no need of examining the crude and often disappointing realities out of doors.

The other kind of nature-study needs no illustrations in its manuals. It merely tries to start the student's interest in something definite and tangible. It presents problems and leaves the answers to the pupil. We will say that the pupil has been stimulated to inquire into the habits of the common robin. He takes a field trip for observation. He may return quite satisfied with his information, but through the skilful questioning of his teacher he discovers that most of his information is very indefinite. He goes back to the field, this time to find some particular phase of the robin's habits. He finds out what he went after. His interest grows with his insight into the problem, and this process is repeated again and again. Now this process is exactly the same as that which the man of science uses in his research work,—to be sure there is some difference in degree. But it leads under skilful management to information and interest that is worth while. It will not concern itself with theories and hypotheses as to the origin of everything under the sun. It deals with relations which are discoverable by children, and it is a sure escape from teleological thinking in this field.

We are evidently here to bury teleology not to praise it. Whatever may be the source of this point of view in our science teaching, we need to be watchful of the explanations we give and the interpretations we accept. If we are most of all interested in the

truth we had better acknowledge the limits of our information than argue backwards from use or advantage to cause. In time this really scientific point of view may help to bring the average mind to an appreciation of natural explanations for natural phenomena.

LARGE COAL MINES.

There are 735 coal mines in the United States which are producing more than 200,000 short tons of coal each annually. In 1911, according to a statement by Edward W. Parker, the coal statistician of the United States Geological Survey, 269 bituminous mines and 168 anthracite mines in Pennsylvania produced in excess of this amount. The average production of these Pennsylvania bituminous mines was 321,773 tons and of the anthracite mines 446,697 tons. The largest anthracite mine had a production of 1,020,420 long tons (1,142,870 short tons). The largest bituminous production from one mine (a Pennsylvania operation) was 1,285,483 short tons. Thirty anthracite mines produced over half a million tons each. Illinois was second to Pennsylvania in large mines, having 93 mines which produced more than 200,000 tons; West Virginia was third, with 59; and Ohio fourth, with 38. The total production of these 735 first-class mines was 253,459,639 tons, or 51.7 per cent of the total production of the country.

PIKES PEAK NOT THE HIGHEST.

What is the highest mountain in Colorado? "Pikes Peak," nineteen persons out of twenty will answer, and incorrectly. The twentieth may know that the two highest mountains in the state are Mount Massive and Mount Elbert, both in Lake County, in the Leadville district. The altitude of each of these mountains, according to the United States Geological Survey, is 14,402 feet above sea level. The height of Pikes Peak is 14,108 feet. Moreover, there are fifty or sixty other peaks in Colorado approximately as high—over 14,000 feet. The lowest point in Colorado is 3,350 feet above sea level. Of all the states Colorado has the highest average altitude, estimated by the Geological Survey at 6,800 feet.

Although not the highest mountain, Pikes Peak is probably the best-known peak in the United States. There was at one time a Weather Bureau station on its summit, and it now has a substantial railway station at the terminus of the highest railway line in North America. It can also be reached by an excellent wagon road and trail which connect the summit with Colorado Springs.

ADJUSTMENT OF THE COMMON SCHOOL CURRICULUM TO THE VOCATIONAL NEEDS OF TO-DAY.*

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Under the demands of modern democracy, public education must serve the whole people and all the people in accordance with their several needs in the enjoyment of liberty and the pursuit of happiness, as well as in the preparation for the intelligent and effective discharge of the duties of citizenship.

To confine such education to the few who may prepare for leadership and to let the great majority shift as best they can, leads to exploitation of the many by the few, to hostile class distinctions, to demagogism and anarchy. Good will on the part of favored classes may check such development for a time, but cannot permanently stay it; for liberty and happiness thrive not on charity but on justice.

General prosperity and the happiness it implies is by no means synonymous with average prosperity. The latter can reach a high mark and yet include much injustice and wretchedness; but general prosperity, ideal general prosperity, finds each individual, other things equal, in the enjoyment of such happiness as is due him in the measure of his social service; and the value of such service in the common life depends upon his ability in his chosen work, upon his realization of its relation to the common life, upon his appreciation of his varied civic and other social and even broadly human responsibilities, and upon the character of the cultural enjoyments that fill his leisure hours and add new meaning and new value to his life.

To secure these things is the purpose of every investment the community or state may make in behalf of the education of its citizens in every walk of life. Nor can any one of these requirements be emphasized at the expense of others or neglected without serious loss or danger to the community or state. For failure on the part of individual members of the social whole in any of the directions indicated will expose them to loss in liberty and happiness, will make of them parasites through some form of exploitation or victims of exploitation on the part of others, will inevitably lower the moral tone and thereby the happiness of the whole.

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*Presented at the Mid-Winter Meeting of the North Eastern Ohio Section on Feb. 8, 1913.

Every phase of hatred and greed, of hypocrisy and arrogance, of wretchedness and crime in the social world can be traced to failure on the part of the community to make, adequate, broad, comprehensive and universal provision for the education of all its members into the ability and joy of work in some freely chosen life-career, into a deep sense of civic and other social responsibility, and into an appreciation of accessible cultural life-enjoyment.

It appears, then, that for its own preservation and progressive development the social body must provide for educational facilities sufficiently comprehensive and flexible to meet the needs of every citizen in preparing for a suitable life-career. Moreover, it appears that the community cannot safely delegate this responsibility to other interested factors without exposing itself and its wards to exploitation.

Now, it is all but generally conceded that the still current organization of public education with its traditional onesidednesses does not sufficiently meet these requirements. It provides, indeed, for a number of professional, commercial, technical and of late also for agricultural vocations, as well as for what it is pleased to designate as general culture; but it is strangely neglectful of those who from inclination or necessity choose industrial careers, although these constitute the vast majority.

It is gratifying, however, to note that this inadequacy is more and more keenly felt and that efforts to supplement it are becoming more and more pronounced among public-spirited citizens, among employers and workers, parents and educational leaders. We meet these efforts in the form of private and public trade schools, apprentice schools, continuation schools, industrial schools and a variety of provisions for vocational guidance; most hopefully, perhaps, in distinct propositions and experiments looking to a reorganization of the public schools with a view of meeting this need without loss, but rather with gain to other vocational interests and to general liberal culture.

The neglect, indeed, of industrial vocations by the school is directly derived from Greek ideals on which our school organization largely rests and which look with contempt upon manual work, an attitude further emphasized with the revival of learning and variously transmitted to us in academies, lyceums, gymnasia and high schools modeled after them.

Gradually, however, and more particularly since the days of John Locke, it came to be recognized that there is cultural value

of a high order in manual work; and with Pestalozzi and Froebel and the discovery of the law of self-activity, the value of constructive and creative doing came to be more generally appreciated and utilized in the work of the schools. This culminated in the adoption of drawing and manual training as cultural subjects in the curriculum, as necessary factors in the work of general education.

At the same time, under the pressure of rapidly growing technical and commercial interests, differentiations in secondary education came to be conceded to life-career motives within these limits in the establishment of technical and commercial high schools and corresponding departments in general high schools, colleges and universities.

But still the great mass, the future industrial workers, the "practical-minded" or "hand-minded" majority are but indifferently considered. After a few years of elementary training in primary departments, the treatment of the subjects of instruction becomes more and more onesidedly abstract, appeals more and more exclusively to the verbal memory and less and less, if at all, to productive and creative activities. Information still has less and less outlet in actual achievement, less and less bearing upon directly practical interests in life. More and more knowledge seems to end in itself and fails to feed the sense of growing power, self-reliance and self-respect,—does, indeed, rather the opposite.

In fact, the academization of the curricula still lies heavy upon our boasted systems of schools. In our elementary schools the vocational needs of the great mass of industrial workers, and even of those who may subsequently enter upon technical training are but scantily considered. In reading all but exclusive stress is upon literature; the story and some descriptive matter usurp attention, interests that call for stimulus and information with reference to matters of industrial and domestic work, of science and engineering, of every-day needs and occupations are slighted or wholly ignored. The same applies in a large measure to writing, although here the "business-man" has secured a share of attention. Arithmetic is thoroughly commercialized; mensuration and concrete geometry, so valuable in industrial, domestic, technical and agricultural life are but transient incidents. The same neglect applies to matters of natural science; nature study and physiology appear, indeed, upon some programs but in time assigned to them they yield to grammar and spelling,

although in life the latter contribute much less to its prolongation and enjoyment than the former—are, indeed, acquired by the majority quite incidentally. Geography and history, as a rule, deal insistently with everything but that which the practical workers need. There is some music or what goes by that name, but the great mass of children are not touched by it, do not carry the songs in their hearts. There is some drawing, but it is prone to be forced from the start into "high art," keeps away from the needs of the worker and rarely serves as a means of self-expression. Sporadically we find some manual training, but the time given to it is ridiculously inadequate, and frequently the method of work is so painfully abstract and so far removed from the children's interests and needs that it becomes not rarely as hateful as grammar. Indeed, at every point the curriculum, in matter and method, tends to academic rather than to vocational ends.

It is gratifying, however, to note that there is growing appreciation of these insufficiencies in the elementary school and a correspondingly urgent demand for its re-organization on the basis of the practical needs of the community and of the time rather than on the ground of theoretical and historic considerations; a re-organization that shall rescue the children from the fetters of an undemocratic uniformity, that shall respect individual need and capacity and afford each child opportunity for trying and finding himself and the niche in which he can best attain joy in a freely chosen life-career of beneficient social service.

It will be impossible to review here in detail the many experiments that have been and are being made in Europe and in our own country. I confine myself, therefore, to the presentation of a few leading phases whose importance seems to be more or less generally conceded.

In the first place, there is general consensus of opinion that there is in matter and method a serious break between the elementary school and the high school; and, on the other hand, an equally damaging disregard of weighty changes in life attitude which come to children with the advent of the adolescent age or about the sixth year of elementary school life. Many children, it is claimed, leave school or begin to fall back in their studies at this time not so much because they are eager to go to work nor because it is necessary for them to do so, but because of lack of interest in the curriculum of the advanced grades which

offer them apparently no avenue to forms of work that seem worth while to them and little relief from the elementary school-grind.

Some relief has been given in such cases by the establishment of schools similar to the Industrial School at the Brownell in Cleveland and to a limited extent by the establishment of technical and commercial high schools, as well as by differentiated courses in general high schools.

Among the more radical plans set in operation to remedy the difficulty, the six-three-and-three plan is probably the most satisfactory. It reduces the elementary school to six years, establishes an intermediate school or "Junior High School" of three years, and a full-fledged high school of three years. In both the intermediate and the high school the courses are flexible and promotion is by subjects not by grades. Instruction throughout is departmental and in the hands of persons who combine the qualities of the teacher with those of the expert.

The curriculum of the intermediate school affords much opportunity for differentiation. All, it is true, share in pursuits that reveal the duties of citizenship and open avenues to the appreciation of the refinements of life. Yet for each one there is opportunity to emphasize what talent, genius, necessity or even inclination may call for.

This flexibility of the course with its wealth of opportunity enables the student under the teacher's guidance to try and find himself, his capacities and enthusiasms with reference to the choice of a life-career. It is, indeed, of the greatest moment that in this he should choose aright, intelligently and not at haphazard; for on this choice depend his happiness and much of the happiness of those his life touches.

Ideally, the curriculum should contain, as already indicated, for civic and cultural purposes all that is found in the current school; but in the treatment of subjects greater stress should be laid upon concrete and practical phases and upon applicability in productive and creative work in directions that appeal to the interests of the students. Thus the empty technicalities of grammar and rhetoric, yield to opportunities for the expression and interpretation of actual thonght and purpose concerning matters of immediate life-interests; the conquest of the horrors of spelling is left largely to incidents in actual need; the puzzles of arithmetic and algebra make room for the intelligent use of number relations in drafting and measuring, in constructive and related research work.

These and similar economies in geography and history, in nature study and physiology, etc., open wide the gates for really vital work, for work that reveals capacities, stirs purpose and crystallizes life-career motive. Throughout, mere information concerning matters that have no such bearing is omitted. In laboratory, drafting and art room, workshop, schoolgarden, and learning and recitation room, at every point of the work, learning by doing and learning for the sake of doing is the motto that inspires teacher and student alike.

Aside from its many internal advantages, this coming intermediate school has the great advantage by its mere existence of holding the children under instruction for a longer period and of bridging the chasm between the elementary and the high school, thereby, as experience shows, leading a greater number of children into the high school proper in its academic, scientific, technical, commercial and other quasi-professional departments.

NOTE—Cokato carries all the children from sixth to seventh grade, and all but two in two years—formerly from 20 to 35 annually—from the eighth to the ninth year. Berkeley, in 1910-11, lost less than 17 per cent in passing from the ninth to the tenth year, as against an average of more than 50 per cent according to Ayers under the old system.

Moreover, the intermediate school so organized brings into the life of the child at an earlier period the influence of men teachers. The value of this cannot be overestimated. It furnishes to the boy realizable ideals and examples he can emulate, and to the girl it furnishes the opportunity to gain respect for the masculine factors in life on the ground of merit. I direct attention to this without prejudice to the equally valuable influence of woman in the school; for I am aware of the fact that the all but exclusive employment of men as teachers in former days had as weakening an influence upon their effectiveness as their excessive feminization has upon the schools today. As in the ideal family we find mother and father, sister and brother, so in the school both elements should be found, if the children are to grow into ideal relationships in a social organization of women and men.

For children who, under the pressure of necessity or of a firmly established desire to enter some trade, do not elect further high school training, other provisions have ben made—most systematically in Switzerland, Germany and France—through the establishment of trade schools, industrial improvement schools and continuation schools.

The chief object of the latter is to continue or keep alive the civic and cultural development of the young worker. To this the trade school and industrial improvement school add intensive instruction in matters pertaining to the respective trade as a whole with a view, in many instances, of protecting the young apprentices against the evils of mere process work. Much attention is, or should be, given to applied mathematics and applied science, to economic and civic relations of the trade, its bearing on the welfare of the community, and other matters that condition joy and a progressive spirit in the work of the trade.

It still remains to add a few suggestions as to the place which work, tending more or less to industrial ends, should have in the elementary school or, with reference to the school organization here proposed, in the first six years of school life. Naturally, differentiation, as proposed for the intermediate school, or specialization as in the trade school or in certain departments of the high school, have no place here. In a large sense, the elementary school until the dawn of adolescent years should be broadly cultural, all-sidedly liberating, affording the children free outlook in every direction of human interest. They should have every opportunity to become familiar with the various phases of natural and social environment, with the conventionalities of life, the interests and occupations of their elders. In judiciously guided productive and creative play-work they should gain control of their own powers of adjustment and self-expression, both individual and social, in leading and in following.

I have already indicated that much still remains to be done in order to vitalize the elementary school in these directions; that the school still is prone to place undue stress on the remote, the abstract, the verbal, the formal with corresponding neglect of the near, the concrete, the actual, the practical; that there still is too much stopping short with mere knowledge-getting and too little opportunity for applying knowledge to actual interests and purposes of life; and that the school thereby becomes distasteful to the children, a hindrance rather than a help in further growth and development.

"If children are forced to take in food foreign to their nature and their mental interest," says Dr. Kerschensteiner, "the school will be a torment to them and to their teachers, and we are fortunate if in this we have not ruined the best that is in them, their individual talent or genius."

It is not within the scope of this sketch to outline a detailed

program for a curriculum of an elementary school that would touch every interest and appeal to every child. Yet it is incumbent upon me before closing to indicate a few points that need emphasis.

Such a program should contain within limits, determined by the spirit of the time and of the civilization in which we live, all that is good in the current curriculum. To this it should add the wealth of opportunity and the flexibility with reference to the needs of individual children that are afforded by the intermediate school as sketched in this report.

In so far as industrial interests are concerned, it should be remembered that familiarity with them and their relations to science and art has become an important element of general or liberal culture for all who mean to take an active part in life. All need to appreciate the value of work, its meaning in the life of the individual, its significance to the welfare of the community and of the nation. No one can boast of a liberal education who has not learned to respect labor and who has not tasted the joy of productive doing.

Hence the need of such doing from the beginning and throughout the elementary school; in current kindergarten ways at first, and increasingly later on in ways that rest upon sympathetic observation and respectful appreciation of the industrial and other vocational activities of the local environment; in play at first, and increasingly later on under conditions that suggest workshop and laboratory, studio and drafting room, garden and field, the constructive activities of the builder and engineer.

In all grades, or at least from the third year on, there should be periods when the children, individually or in groups, have opportunity to choose occupations wholly free from compulsion; when the teacher is at their disposal as a sympathetic helper, answering questions or suggesting books or experts that can give the needed help. Under such freedom, children put forth effort which compulsion and even suggestion can never attain. Moreover, it furnishes almost ideal occasion for the child to try himself in various interests and skills.

To the teacher, too, it provides the best and surest indications of the children's capacities, talents and enthusiasms in his effort to guide and guard the children aright with reference to their vocational destiny.

Permit me in conclusion to sum up in a few sentences the considerations that are to guide all public education, in which prep-

aration for industrial careers is in no way less worthy and less important than preparation for any other calling.

In the first place, public education in a democracy posits as its chief and universal aim preparation for citizenship. This involves efficiency and joy in some worthy work and a sincere willingness to place such efficiency at the service of the community or of the state under conditions of mutual justice and good will. It involves further, on the part of all citizens, a fair degree of general culture, the sympathetic appreciation of the duties and enjoyments of life.

In a general way, every active member of a community is efficient in the measure in which he knows his environment in its relations to his well-being, and has learned to adjust himself to its necessities, as well as to adjust the environment to his needs; in other words, in the measure in which he has cultivated productive and creative power and consequent joy of work.

Nor is such appeal to the productive powers to be confined to possible or probable future workers. It is needed by all pupils in the elementary school, not so much for the skill it may bring, but more for its influence upon character-development, its cultivation of sense of power, of self-reliance, of initiative, of the habit of seeking knowledge less for its sake than for the sake of increased power to achieve.

In the elementary school, therefore, as well as to some extent in the intermediate school, the curriculum will favor studies that stimulate the desire of concrete achievements and consequent sense of power. Thus abstract grammar and much of current literature will be postponed and yield to applied mathematics and applied science with stress quite early upon concrete geometry and physics and the supreme "joy of making." Similarly, drawing will be placed more in the service of productive and creative life, serving self-expression in drafting, planning and decoration, while fine art will grace a later period.

Most prominent, perhaps, in the inner organization of the school work will be the constant effort to stir individual initiative with its train of self-reliance and self-respect on the part of the children, the consequent suppression of dead-level uniformity and encouragement of individual judgment. To this will be added the beneficient moralizing influence of social work, of deliberate division and co-ordination of effort in the attainment of common ends.

I am aware that much of this and other features which I for-

bear to touch upon lie in the future, partake of the nature of ideals; but progress needs ideals, cannot live without them. Moreover, the rapid development of public education in the direction indicated, both at home and abroad, together with the growing clearness of the conviction on the part of the people in many localities that among the natural resources of the community none is more precious and worthier of conservation than its children and that no investment yields richer returns than investment in their education, gives assurance that realization is within reach.

Since 1880 the total value of the mineral production of Alaska has been $207,000,000, of which over 90 per cent, or $195,619, 776, has been in gold, according to A. H. Brooks, of the United States Geological Survey.

THE BANANA—A FRUIT IN A STERILE PACKAGE.

With the increasing demand for fresh fruits at all seasons of the year has come the difficulty of supplying them in a condition in which the dangers of contamination are largely averted. Decay is one of the limiting factors in the use of fresh fruits. Among the many fruits there is one which is equipped in its native form with a protective covering that calls for more than passing mention. Some time ago *The Journal of the American Medical Association* emphasized the advantages afforded by the banana as a wholesome food and ventured the suggestion that this fruit, though growing in popularity, is still underestimated in America households. The banana consists, in its green state, largely of starch and water. The essential change during the process of ripening is a conversion of the starch into sugar. The rate o fripening is dependent on the temperature. The edible portion of each fruit is packed away in a peel which serves a more useful purpose than has hitherto been realized. Experiments on the fruit in different stages show that the inner portions of the pulp of sound bananas are practically sterile. the peel is singularly resistant to invasion by bacteria. Even when bananas were immersed in fluids containing disease germs they did not penetrate into the interior. The probability of infection through the peel is therefore slight, though germs on the peel might be transferred to the consumer's fingers and thence to the mouth. This is an interesting example of a food delivered by Nature in practically sterile packages. Nature's wholesome service should not be undone by careless methods of marketing such foods.

A LESSON FROM THE HISTORY OF NUMBERS.

By R. D. Carmichael,
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The study of numbers is the first mathematical subject to engage the child's attention; and thus, in one sense, it is the most elementary topic in the whole field. But it is also a subject from which the most advanced mathematician never gets away. He always finds in it unanswered questions and problems which baffle his ingenuity and put to rout his whole army of methods of attack. I may mention one of these which has repulsed all his assaults up to the present time, though for a quarter millennium it has engaged his frequent attention. It is the so-called great Fermat problem: To determine whether there exist positive integers x, y, z, n, where n is greater than 2, verifying the relation

$$x^n + y^n = z^n.$$

One of the German mathematical societies holds a prize of a 100,000 marks, approximately 24,000 dollars, to be awarded to him who first solves the problem.

It is not our present purpose to discuss the unsolved problems, which abound throughout the subject and which show its vitality as a field of research, but to turn rather to a review of the history of the concept of number itself with the belief that this review will lead to a lesson of value.

Let us in thought go back to the very beginning of mathematical investigation. What must have been the first definite mathematical conquest of the human mind? You will probably agree that it was in the recognition of the fact that a tree, a bird, a mountain, a nut, a bird note, an animal, a thought, all have something in common; namely, the quality of oneness. The coming to this conception was the beginning of all mathematical investigation. Here was the primal germ of all mathematics.

It appears to me that this was by no means an easy conquest. Initially it was hard to grasp the idea, on account of its being abstracted from all concrete representation. There is nothing in the material world corresponding to this concept of oneness; the notion is a pure creation of the intellect.

As soon as a word has been chosen to represent the idea it is much less difficult for another individual to attain it; for the word is a definite thing to which to attach the idea. There is

no doubt that the word "one" is a great aid to the child in grasping the idea of "oneness."

It appears that the next step in mathematical progress was to adjoin to the concept "one" the concepts "two" and "many." The philologist gives the best evidence for this when he points out that a large proportion of very ancient languages have the three grammatical numbers singular (corresponding to one), dual (corresponding to two), and plural (corresponding to many).

From this very primitive method of counting, in which the number system consisted of "one," "two," "many," by a slow process of evolution, the entire system of positive integers was evolved. To accomplish this end required many generations and the best activity of some of the rarest intellects of the human race. The earlier detailed development is lost in the obscurity of unwritten history; some of that which was later is preserved for us in the mathematical books of the ancient Greeks and other peoples. Lack of space forbids our going further into this matter.

The next problem which engaged attention was that of fractions. It must at an early time have been forced upon the notice of our primitive ancestors, as for instance when two hunters came to divide the spoils of the chase and only a single animal had been captured by them. But it was reserved for relatively modern times to reach any satisfactory theory of fractions. The Egyptians seem to have been among the first to make any headway at all; and their methods were exceedingly cumbersome. There is something pathetic about the way in which the human mind has struggled with fractions. The Greek mathematicians introduced the Egyptian methods to their countrymen; but, notwithstanding the fact that they produced a Euclid, they had yet no one who could unravel the tangled intricacies of operations with fractions. It was a problem which they had to pass on to future generations. The Greeks could write philosophies which men perhaps do not yet understand; but their knowledge of fractions was much less than that of the common-school pupil of our day.

The whole history of the development of the number system is an account of the way in which the human mind has struggled with one after another of the problems to which, from time to time, this development has given rise. The introduction of the negative numbers and zero was one of these; lack of space forbids our going into this question. Much has been written and

spoken concerning the pedagogical methods by which these are to be introduced to the student. We turn from this, therefore, to another topic on which, in our opinion, thinking is much less definite and accurate and current pedagogical methods are further from being satisfactory. Let us consider the notion of an irrational number.

The concept of irrational number was definitely formulated in ancient times. The Pythagorean proposition thrust it forcibly upon the attention of the Greeks. When it was learned that the square upon the hypotenuse of a right triangle is equal to the sum of the squares of the legs, it was natural to inquire what is the length of the hypotenuse x of a right triangle whose sides are 1 and 1. That is, what is the value of x such that $x^2=2$?

It is easy to show that no rational number x satisfies this equation. In the first place it is evident that x cannot be an integer; hence, if it is rational, it must be a fraction. Now every fraction can be reduced to a form in which the numerator and the denominator have no factor in common except 1. Therefore, if x is rational, it can be written in the form $x=\frac{m}{n}$, where m and n are integers with no common factor except 1. Substituting this value of x in the above equation and clearing of fractions we have $m^2=2n^2$. Since the second member of this equation is even the first must be even also; that is, m is even. Then let us write $2M$ for m. Our equation then becomes $4M^2=2n^2$; whence $2M^2=n^2$. From this equation, by the method employed above, we may now show that n is even. But we have alraedy shown that m is even. Hence, m and n have the factor 2 in common, contrary to the hypothesis that they have no factor in common except 1. It is the assumption that x is rational which has led us to this contradiction. Therefore x is not rational; that is, there is no rational number x which satisfies the equation $x^2=2$.

In view of this conclusion there are two courses which are open to the mathematician. He may say that there is no number x which satisfies this equation. And his method of procedure would be entirely legitimate. He would undoubtedly make this assumption if it served his convenience. But it is convenient to him to be able to solve every algebraic equation; and it is also convenient in the applications of mathematics. As a consequence the mathematician has chosen to do this: Since no number among those previously considered by him satisfies

the above equation he will define numbers which do satisfy this and all similar equations.

How is this definition to be made in the most convenient and satisfactory way? In the answer to this question there has been much vague thinking; and in some places it persists in the schoolroom to this day, though there is no valid excuse for it. It was reserved for the nineteenth century to make this definition in a way which meets the proper demands of clear and accurate thinking. Let us illustrate the method by *defining* a number which satisfies the above equation. We shall employ the method of the German mathematician Cantor.

We wish to define a positive number A having the property that $A^2=2$.

It is evident that A lies between 1 and 2, so that we have the inequalities

$$1<A<2.$$

If we employ the usual method of extracting the square root we obtain the further inequalities

$$1.4<A<1.5.$$

If we make repeated use of the same process we have ultimately the infinite sequence of inequalities

$$\begin{gathered}1<A<2\\1.4<A<1.5\\1.41<A<1.42\\1.414<A<1.415\\1.4142<A<1.4143\\\cdots\cdots\cdots\cdots\end{gathered}$$

The outer limits are, as it were, pinching down more and more closely on the number A. We *assume* that a number exists which satisfies every one of the above infinite set of double inequalities and this number we *define* to be A. The reader will notice that there is involved both an *assumption* and a *definition*. There is no way to avoid the entrance of both of these elements into our discussion. They may be put into different forms, but both must actually be present in whatever way we deal with the matter.

It is impossible for us, in our limited space, to go further into this discussion. We must be content with the above illustration of the general theory.

In following out the convention that every algebraic equation

is to have a solution, we find the necessity of further enlarging our number system. Among the numbers which we have so far defined there is none which satisfies the equation

$$x^2+1=0.$$

As in the previous case, we are at liberty either to say that this equation has no solution or to define a number which satisfies it. Mathematicians have chosen to do the latter. Since no number of our system, as previously formed, satisfies this equation we simply adjoin a new number i which by definition has the property

$$i^2+1=0.$$

It must be understood that this is purely a definition; it is not a result obtained by the processes of reasoning. In fact we have explicitly ***assumed*** the existence of the number i. This number i may be denoted by $\sqrt{-1}$; but we must remember that this symbol has no meaning whatever except that which is given to it in the definition of the number i.

Since this new number i is a pure creation of the human intellect, we are at liberty to define its laws of operation and combination in any self-consistent way which we like; and in doing this we shall evidently be guided by a sense of convenience and a sense of the beautiful. For instance, what shall I mean by the product $\sqrt{-a} \cdot \sqrt{-b}$ where a and b are positive integers? In the discussion of irrational numbers we agree that $\sqrt{-a} \cdot \sqrt{-b}$ shall be equal to $\sqrt{ab}$, if a and b are positive. Shall we follow out the analogous law and say that $\sqrt{-a} \cdot \sqrt{-b} = \sqrt{ab}$?

This is what Euler did. But nowadays we choose rather to say that $\sqrt{-a} \cdot \sqrt{-b} = -\sqrt{ab}$.

Whatever we do is purely a matter of definition. Either plan is legitimate; only we must consistently follow some plan.

This brief and imperfect review of the number system leads us a certain way forward in the discussion of numbers. Clearly, we have hardly been able to touch the real difficulties of the matter. Let us emphasize these difficulties by thinking for a moment as to the meaning which should be given to the expression 3^m where $m=\sqrt{2}$. There can be no doubt that this is a question of grave difficulty when approached for the first time. Or, even worse, what meaning shall be attached to the symbol 3^m where $m=\sqrt{-2}$?

The essential difficulty of the whole matter can be brought out better still by going back to the very beginning of a logical

development of the subject and asking the fundamental question, *What is a number?* We started out with the positive integers which were defined by the process of counting. Then we increased our number system by repeated adjunctions of other classes of numbers in order: (1) Fractions; (2) Negative numbers and zero; (3) Irrational numbers; (4) Imaginary numbers. Having done this, what definition may we employ sufficiently comprehensive and exact to define the resulting totality? This problem is one of difficulty. We shall not attempt its solution here, but refer the reader to the treatises on the number system of algebra.

A further emphasis should be put on a fact which we have already mentioned twice; namely, this: There is no logical compulsion in making our number system as comprehensive as that which we have defined. In fact, in very recent years there has been much consideration of systems which are limited in one way or another. We may confine attention to rational numbers, or even to integers; or the system may be limited, in various other ways. For instance, we may confine our attention entirely to a finite group of integers. I mention these historical facts simply for the purpose of emphasizing the arbitrariness which actually exists in the definitions of our usual algebraic number system.

Perhaps the reader is already feeling that it is time that these historical remarks should be brought to an end and that we should turn our attention to the lesson which is to be derived from them. This we shall now do. First of all, I should say that the lesson is chiefly to be drawn from the history itself. I can give you only small assistance by pointing out what seem to me to be some of the chief elements in the lesson which we are to learn from these facts.

Probably the best lesson which we should get from this historical review is that there is a lesson to be learned. The history of mathematics has something to say to the teacher which it is worth while to the teacher to hear. Our account of the history of numbers has been to no purpose if it has not made this fact stand out. It is to be hoped that there will be among mathematics teachers a much-increased interest in the history of their subject. Those who have not read a good elementary book on the subject should find an early opportunity to do so.

The high-school student of algebra and the freshman must come face to face with the progressive development of the num-

ber system or he must dodge it. Usually, he dodges it; and I am not saying that this is what he should not do. I think that he should and must dodge most of these intricacies. But the teacher who leads him through this field where the way is often rough and the pitfalls are many should know the lay of the whole ground so as to be able intelligently to guide the untrained feet in the way of safety and progress.

At best the way will be difficult. The student's thinking will be indefinite and often hazy in the extreme. But, if the recapitulation theory of embryology and evolution is to be transferred to the field of thought, it is only what we should expect. The schoolboy in a few years is clambering over the way which the race found out first only after millenniums of labor. It is no surprise that he is often baffled, that many of his number never get safely across what to them is a barren waste. Here it is easy to expect more of the student than is just.

The essential difficulty of the subject and the pressing necessity that the student make some acquaintance with it puts a heavy burden upon the teacher. I have a high regard for the teaching profession and for those who are engaged in it; but this does not prevent my seeing our shortcomings. It is trite to say that a prerequisite to progress is a clear conception of where improvement is needed and a method for bringing it about. I believe that I put my finger on a sore spot of our teaching when I touch the matter of our schoolroom development of the number system of algebra. No doubt the responsibility for this state of affairs lies first of all upon those who have in hand the matter of laying out courses of study for those who are to become teachers. But every individual teacher should also carry his part of this burden of responsibility. Certainly, something is wrong when men and women who have not a clear idea of the development of the number system are trying to induct the youth into a knowledge of it. It is a case of the blind leading the blind. Of course there are noteworthy exceptions where the teacher is well-prepared in respect to this difficult task; but this should be the rule and not the exception.

I believe that every teacher of high-school or freshman algebra should be acquainted with the elements of a logical development of the number system. It is sincerely to be hoped that our generation will see the attainment of this important end. By becoming acquainted with this important body of doctrine each individual teacher will contribute to it. My object in this

paper will have been attained if I have in any degree speeded the impulse for better acquaintance (on the part of teachers) with the logical foundations of the mathematical sciences.

SWISS SCHOOLS.

"Nearly 90 per cent of the teachers in Switzerland are men," said W. K. Tate, supervisor of rural schools in South Carolina, to a conference of educators at the United States Bureau of Education. Mr. Tate has just returned from a three months' investigation in Switzerland under the auspices of the Bureau.

"Five hundred dollars is considered a good salary for a teacher. After a lifetime of service he may go as high as $800. Living is cheaper there than here, however, and in addition to his salary he is furnished with a dwelling, a certain amount of garden land and wood for fuel. His dwelling is generally in the same building with the school. His position is of considerable local importance. Aside from his duties in the schoolroom he is often secretary of the local creamery association, leader of the village band, organist in the church, and general intellectual guide for the community.

"When a teacher is engaged for a position it is for life or a long term of years. He settles down with the people whose children he teaches, and generally expects to make that particular job his life work. And he stays. Changes are rare. Twelve new teachers in one year in a system of 240 was considered very unusual. The record for continued service in the same village is held by a teacher in Thurgau, who has occupied the same position for sixty-five years. One teacher that I visited has held his position for twenty-four years and his father held the same position for thirty-five years before him.

"One of the most attractive features of the Swiss Schools is the cordial personal relation that exists between teacher and pupil. There is nothing of the military in the discipline of the school; no lining-up; no marching to classes. When the children go to the classroom, they shake hands with the teacher, greeting him as if they had not seen him for a long time and are really glad to see him. The whole relation is one of charming naturalness and kindliness on both sides.

"In the Swiss cantons school is in session from 8 to 4 in winter time, with an intermission of two hours at noon (three hours for the younger children). In summer the children have to be at school at 7 a. m.

"Failure to be 'promoted' is rare. After the four years of elementary training in the primary school, prescribed for everybody, the children proceed into schools that are carefully differentiated for the various types of children. Some of the children enter upon a technical training; others are sent through the gymnasium and ultimately to the university; and still others are prepared for business life or any other suitable career, according to the ability and aptitude of the individual boy or girl."

THE TEACHING OF GEOMETRY AT TUSKEGEE.

By D. W. Woodard,
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One day a group of Tuskegee students was engaged in putting the finishing touches to a new building on the Institute grounds. To one young man, who was learning the carpenter's trade, was assigned the work of laying some molding. For quite a while he pursued his work quickly and successfully. Then his job led him to a certain corner of the building which deviated considerably from the usual right angle. What was he to do? Never before had he laid molding around such a corner. Now the problem consisted in finding the angle for cutting the molding so as to make a proper fit. Failing to think out the problem, the student by a trial and error method was finally able to make the molding fit as desired. But this trial and error method involved not only a loss of time but also a waste of material.

This happened on Friday, a day on which this particular carpenter was engaged wholly in industrial work. According to the Tuskegee system, a "day" student in a week spends three days at his trade and three days in academic work, the "trade" days alternating with the "academic" days. On the day after the incident mentioned, the student reported the affair to his class in geometry. After he had attempted to give a statement of his difficulties, the class visited the scene of the event. Again the student explained the situation. Finally, a method was worked out on the spot whereby the molding could be cut without waste. But the method arrived at, while it eliminated all waste, was unsatisfactory in that it was very slow in operation. On the next "academic" day the problem was again discussed and referred for further discussion to a committee of three carpenters (students) who were members of this class in geometry. This committee consulted the instructors in carpentry and all other available sources of information. Altogether three methods were proposed for the task. A model representing the corner of the room was brought into the classroom together with pieces of molding, a saw, and the like. Each method was actually exhibited before the class and the geometrical principles concerned in each were thoroughly discussed.

I have related somewhat in detail the above incident because it exemplifies the character of the work in mathematics, and particularly in geometry, which is attempted at Tuskegee. As has

been stated before, every "day" student at Tuskegee pursues for six days of the week a prescribed academic course and trade work on alternate days. "Night" students spend six days in industrial work and five evenings in the academic department. Such a system necessitates a close correlation of academic and industrial activities if the student is not to be keenly conscious of a lack of continuity in his work. The fact that the trades constantly involve more or less of the application of mathematical principles, makes mathematics a subject peculiarly fitted to bring about the correlation of the two phases of the work. The persistent correlation of the mathematics with the industrial work causes the instruction in mathematics at Tuskegee to differ considerably from the traditional presentation. The differences are found not only in the character and content of the problems, but also in the scope of the work, the distribution of the emphasis in the instruction, and the method of presentation.

A noteworthy fact in connection with the incident related above was this: when the student reported his difficulty, the teacher at once dropped his plan for the day and proceeded to the solution of the problem. Neither the teacher nor the students stopped to question whether the situation as reported involved any immediate application of the lesson assigned for the day, or, indeed of any lesson they had had so far. The central thought was: "here is a situation which calls for a solution which is clearly geometrical in nature. We are studying geometry in order to be able to solve such problems." As it happened, this problem compelled the class to work out several new propositions and to review others. It is significant that, through the interest awakened by the practical situation and by the actual handling of the material, these several new propositions were disposed of in a fraction of the time required for the same propositions under the usual circumstances. My experience indicates that this is generally true for work attempted in this way.

In contrast to the feeling that the student generally has that the problems solved in class are given for the express purpose of illustrating some principle already learned, the idea brought to the front here is that the mathematical principle is developed to give the student an economical method of adjusting himself to a new situation, that the principle is worked out for the sake of the problem. The effect of this point of view upon the attitude of the student toward the subject and upon the development of the subject in the course will be discussed later.

Reference has been made to the fact that a problem under consideration was referred to a committee of three members of the class, who by their trade were particularly concerned. This grouping of the students into committees for the study of special problems is a distinguishing feature of the method employed at Tuskegee. The idea arose in this way: Two students belonging to the same trade differed in regard to a matter which had been reported to the class. When the teacher appealed to the other members of the class following the same trade, it was found that the disagreement was quite general. Thereupon a group was formed consisting of all members of the class belonging to the trade, for the purpose of studying the matter and making a final report to the class. Not only did this group of students clear up the matter under discussion, but, to the great surprise of the teacher, they searched their trade practice and brought in all the problems involving geometry that they could find in the short period of time given them in which to make their report. From that time, whenever a student reports to the class a matter which he thinks calls for a geometrical solution, the whole problem, unless the solution is obvious, is referred to a group of students. In this group are placed students in connection with whose trade the problem has arisen, together with at least one student whose trade is different from that of the other members of the group. Of this group the student reporting the affair is the chairman. The group meets at his call and he informs the teacher of the progress of the work of the group. The purpose in associating with the group a student whose trade is different from that of the other members of the group is to compel the students to translate the situation from the trade jargon into language intelligible to other members of the class. The educative value of this feature is obvious.

The greater part of the work of the class is carried on by means of the reports of these groups. The plan of procedure is as follows: (1) Report of the problem by student; (2) assignment of certain students to a group under the chairmanship of the student reporting; (3) meeting of the group to consider the problem; (4) if the problem is not solved at the group meeting, a preliminary report is made to the class where the matter is discussed and the problem more definitely formulated from the standpoint of geometry; (5) further meetings of the group until the problem is solved and reported to the class in finished form. Frequently a group will hold as many as a half dozen

meetings and make quite as many reports to the class before being dissolved. I have known a group to have a matter under consideration as long as five months. Every student belongs at all times to one or more of these groups. Exceptionally bright students are attached to several groups. If a student becomes interested in a problem under consideration by a group to which he is not regularly assigned, he may of his own will attach himself thereto. Every student is assigned to a group which works out systematically the geometry involved in the operations of his own trade. In this system, too, opportunity is given the teacher to distribute the work according to the ability of the individual members of the class.

Frequently students of different trades are grouped together because of a community of interests in trade work. Thus, carpenters and brick masons were associated together to consider the construction of the brick arch because the carpenters make the forms about which the masons build the arches. Blacksmiths and wheelwrights work on the building of the same vehicle and hence are mutually helpful when assigned to the same group. Unexpected points of contact between the trades often appear as the following incident will show. When in the recitation the teacher called for new matter, one student, a wheelwright, spoke of the method employed in his shop in "squaring up" the shafts of a buggy. He wanted to know why the method always gave the desired result. His chief explanation of the mechanical process was not very clear to the class. Further dicussion was postponed until the class could visit the shop and actually see the operation described by the student. As soon as the wheelwright sat down, a carpenter arose and said that there were "squaring up" processes in his trade, especially in connection with window frames, and so on. A group to consider in detail such problems was thereupon formed consisting of carpenters and wheelwrights with the wheelwright mentioned above as chairman. When the class visited the wheelwright shop, not only did the student explain the operation of "squaring up" the shafts, but he also showed several other operations connected with the construction of the vehicle which involved geometry. This has been my almost invariable experience. Whenever the class has been taken to a shop to have explained an operation there carried on, almost without exception unlooked for geometrical problems have come to light. This is one reason, aside from another which I shall give later on, why classes should be taught as far as

possible at places where the operations under discussion are taking place.

Now I wish to call attention to a point which, I think, shows an important phase of these experiences. While in the wheelwright shop, not only did the class under the leadership of the student wheelwright see performed a useful operation, but the students received training in analyzing a real situation and formulating the geometrical propositions connected therewith. They did real thinking, thinking in direct relation to a concrete situation. This analysis of a situation and this sharp definition of its problematic character finally leading to the formulation of the geometrical propositions involved constitute, in my opinion, a most valuable part of the training of the students, valuable alike from the standpoint of geometry and from the standpoint of their command of the theory and practice of their trades.

In this connection I might mention that, when a problem reported by a student requires the presence of the class at a certain place, the details of the arrangements of the trip are left as largely as possible to the student. He is made to feel that the success of the venture depends in great measure upon his efforts.

The attempt is made to build up the geometry about the situations which arise in the daily work of the students at their trades. There is no lack of such situations. In fact I have found it a matter of impossibility to work out in class all of the real problems reported by the students. There is always a period during the recitation which is devoted to the hearing of new problems. So eager are the students at times to have *their* problems brought before the class that the teacher is frequently at a loss, in the face of many such requests, as to which problem to consider first. On such occasions an appeal is made to the members of the class and they decide what is to be the order of the recitation. In great part the class teaches itself. The teacher is a guide, a friend who is interested in everybody's problem.

It can be seen from the foregoing that the instruction in geometry at Tuskegee is by no means confined to the ordinary classroom exercises. When a student in his experience meets that which he thinks has the remotest connection with geometry, he will, if possible, without consulting the teacher bring the actual material to the classroom. On one occasion a student brought to the classroom a good part of the gearing of a buggy. I do not know to this day how he managed to get it there. Whenever

it is inconvenient or undesirable to bring the necessary material to the classroom, the recitation is held where the material is to be found or the operation under consideration is being carried on. It may be in a shop or at a new building in the course of construction. Problems are solved in their natural setting. The atmosphere of the classroom, just because it is a classroom with the traditional furnishings, militates against the proper appreciation of a concrete situation in many instances. As I have found to my cost, it is one thing to sit down in a classroom and imagine the manner in which a piece of work is being done and quite another to be on the spot and attempt to explain an actual operation surrounded by the conditions under which it is usually effected. In line with this thought, I might further add, that I have been amazed to see the increased fluency on the part of a student when he is in his own shop explaining his own work.

Just as the method of grouping the students for the investigation of certain problems arose by accident, so another important feature worked itself out without any special design on the part of the teacher. One of the students asked the teacher for permission to consult him about a problem that had arisen in some of his trade work. The teacher set aside a Tuesday evening for the conference and casually remarked in class that all other students who were interested in the problem might meet at the same time. When the appointed time came, the room was full of students. This meeting was so successful that it was agreed to meet on the following Tuesday. From that time this weekly conference has been held. Attendance upon this meeting is absolutely voluntary. The students are free to come and go as they please. The fact that a considerable number of the students taking the course in geometry will voluntarily spend more than an hour each week in such work bespeaks more than anything else their interest in the subject. These meetings are devoted almost wholly to the discussion of real problems. As has been said before, there are so many problems reported to the regular class that it is impossible to discuss them all adequately in the recitation period. The weekly meeting, now known as the Geometry Club, affords an opportunity for the discussion of these surplus problems. There is no prearranged program, no particular order of business. The conduct of the meeting is largely in the hands of the students, the teacher taking his place as one of them. There is no formality, no hurry. When a student has a matter to present, he virtually takes charge of the discussion. In

spite of the fact that there is no formal plan of procedure, I have never known a meeting in which there were not helpful discussions. I believe that some of the most valuable work of the course is done in this meeting. Certainly the most enjoyable work is here done.

The questions might properly be asked: In the attempt to build up the geometry around concrete situations, what becomes of the rigorously logical treatment which is supposed to be associated with courses in geometry? When a student has finished such a course as described, what conception of geometry as a science has he attained? How does his conception of the subject compare with that of the student trained according to traditional methods? To answer these questions, let us consider again the disposition of the practical problems reported to the class. In the first place, no problem is considered solved until every proposition has been reduced to the conventional mathematical language. Then, too, from the system of handling the problems, it results that a certain minimum of propositions is in possession of all the members of the class; but members of certain groups may have problems as yet unreported to the class that have compelled them to work out and study new propositions in many instances considerably in advance of the minimum already mentioned. In one of the best reports prepared by any group, it was found that the students had formulated correctly the fundamental proposition connected with their problem, but, after much groping about, discovered that this proposition necessitated the proof of several propositions unknown to them and to their class. These propositions they had numbered and set down in their proper sequence, showing that they fully appreciated what is meant by the logical order of propositions in geometry. Of course, few reports are so thoroughly worked out prior to their presentation before the class. But finally all reports are cast into this shape. I do not feel that there is any loss in such rigor as might be expected of an elementary course in geometry, but, on the contrary, the critical attitude developed by the analysis of concrete situations in all their complexity and their abstract geometrical formulation, is, I believe, of enduring advantage to the student. Ordinarily few students in elementary geometry courses receive any training whatever in the formulation of propositions from given data.

When the student has finished such work, he has a sequence of fundamental propositions, and above all these propositions are not only connected in his mind in logical order, but they are

associated with his vital interests. They have an interest and value outside of themselves. They represent a source of methods of doing things. They are classed with his saw, his spirit level, his trowel, his lathe and other tools and machines. From this close association of geometry with his life experiences, the student gets the notion that the same kind of common-sense reasoning used in ordinary situations is to be brought into play in geometry. He becomes acquainted with the subject in an intimate way; it loses its character as a very unusual procedure invented to call into action some particular brand of mental power never used before nor afterwards.

In this work the student builds up his own geometry. He sees each bit of the structure put into place before his very eyes. At certain intervals, the whole edifice so far constructed by the class with emphasis upon the dependence of its various parts is discussed in class. If a proposition arises from a matter reported by a student, it is often named after him, as, for instance, the Jones proposition. In a word, the subject becomes properly and helpfully orientated in the mental life of the student. One of the most gratifying experiences of the writer as a teacher was to have one of his students who had graduated from the institute, on a recent visit relate to the geometry class how in a given instance in his work as a brickmason he had been able to use his geometrical knowledge at a critical time.

While we are speaking of the sequence in which propositions arrange themselves in conformity to the demands of the practical problems brought before the class, it may be of interest to recount the manner in which the subject of the circle was approached during the current school year. I did not say, "On the next day we shall begin the study of the circle. Study page so-and-so," but this, "One of our students, a carpenter, wishes to take us to see some repair work on a circular wooden pillar of the library building. The class will meet there instead of in the usual recitation room." The essential part of the operation for us as a class consisted in finding the diameter of the circular pillar from the outside. The proposition that justified the method used was, the diameter of a circle is equal to the distance between two parallel tangents. The point that I wish to make is, that the consideration of the circle was begun, without any preliminary preparation, with a discussion of a proposition concerning tangents. But, under the stimulus of the real situation the necessary notions were immediately developed in an interesting and prac-

tical manner. The rapidity with which the class in the face of a real problem has covered the ground necessary to its solution has been a source of great astonishment to me, brought up under the usual methods. Under ordinary circumstances, perhaps, I should not have had the temerity to begin the formal consideration of the circle at a point not sanctioned by the traditional classroom procedure, but I am fully convinced that at least in this kind of work any real problematic situation involving the idea to be discussed may be used as a first point of contact with the particular topic. At Tuskegee interesting experiences of this type may be trusted to develop a sequence of propositions which invest the geometry with a most desirable significance for the student.

A short list of propositions so formulated by the students may be of interest.

OCCASION	PROPOSITIONS
1. A carpenter was compelled to construct an arch under a stairway where the floor prevented his getting the center in the usual way. He contrived an instrument giving rise to the proposition to the right.	1. If an angle is moved so that its sides constantly pass through two fixed points, its vertex describes the arc of a circle.
2. Justifying the use of the centrolinead, an instrument used by the students in the course in architectural drawing.	2. (a) If line No. 1 is bisected at right angles by line No. 2 so that one-half of line No. 1 is a mean proportional between the segments which it cuts off on line No. 2, then line No. 2 is the diameter of a circle passing through the extremities of line No. 1. (b) Consider the angle formed by joining the extremity A of line No. 2 to the extremities of line No. 1. If this angle is moved so that its sides constantly pass through the extremities of line No. 1, the bisector of the angle will constantly pass through the extremity B of line No. 2.
3. Justifying a part of the process used in the blacksmith shop in connection with the adjustment of the gearing of a vehicle.	3. If in a quadrilateral one pair of opposite sides consists of equal lines and the diagonals are equal, the remaining two sides of the figure are parallel.
4. Justifying a method used in getting the cut on molding laid around non-rectangular corners.	4. The diagonals of a parallelogram bisect the angles from whose vertices they are drawn when the distance between one pair of opposite sides is equal to the distance between the other pair.

A long period of study and many reports on the part of a group of students were required before the propositions given in the case of the centrolinead were correctly formulated and proved. This selecting of the conventional terms of geometry and the fitting of the terms to a concrete situation insures the full grasp of the meaning of these terms on the part of the student. The student's "mental definition" mentioned by Prof. Dewey and the true mathematical definition are more likely to agree than under the usual presentation. It is a truism that the test of a student's understanding of a term consists in his ability to use the term.

The points that I have tried to emphasize here have been:

1. The grouping of the students according to their practical interests in problems affords a method for keeping the instruction in geometry in constant contact with the real life of the student.

2. The student creates his own geometry. Propositions are gathered into a logical sequence in response to a felt need.

3. The abstract formulation of concrete situations is a valuable feature of the work.

4. This sort of work in geometry gives the student a grasp of certain theoretical and practical aspects of his trade not otherwise possible. His geometrical knowledge is a source of help in situations where ordinary rules break down. Instances could be furnished of this fact.

5. And last but not least, the work is interesting and enjoyable both to the teacher and, so far as can be observed, to the student.

In closing I wish to make two quotations which I think relevant to the above discussion from an article by Prof. Dewey on "The Psychological and the Logical in the Teaching of Geometry" (*Educational Review*, April, 1903).

"But he (the student) also needs the habit of looking at definitions and propositions with reference to the real experiences which they express. More than any other one thing it would seem as if the high school pupil, in particular, were at the point where his greatest need is neither merely intuitive nor strictly demonstrative geometry but rather skill in moving back and forth from the concrete situations of experience to their abstracts in geometric statement."

"The serious problem in instruction in any branch is to acquire the habit of viewing in a two-fold way the subject-matter which is taught day by day. It needs to be viewed as a development

out of the present habits and experiences of emotion, thought and action; it needs to be viewed also as a development of the most orderly intellectual system possible. These two sides, which I venture to term the psychological and the logical are limits of a continuous movement rather than opposite forces or even independent elements."

IS THE CIGARET THE CULPRIT?

The lung capacity of this year's freshman class at the University of Wisconsin is 246.2 as compared with 254.4 for the freshman class last year, a loss of 8.2, while in power of forearm there has been a gain from 100.7 to 118. This gain in power of forearm is attributed by Dr. Elsom, who had charge of the examination, to increase of physical training in high schools and graded schools. However, the loss in lung capacity seems rather difficult to account for, and lung capacity is doubtless of greater importance than strength of forearm. We wonder if the cigaret has anything to do with the matter? If such is the case new impetus will be added to the crusade against the use of the cigaret by school boys which has been launched by the school people of the state.

TEACHERS NEEDED IN CHICAGO.

There is at present a great demand for high school teachers in Chicago. This is especially so in the sciences, mathematics and manual training. The rapid growth of the city and the opening of two great new high schools is the cause of this need. Here is a splendid opportunity for teachers, in the subjects named, to get into this big system.

In science the most urgent need is in departments of physics and chemistry. There are now no eligible names on the list, all candidates having received appointments. It probably is not generally known that the maximum salary has recently been raised to $2,600.00. Teachers of considerable experience are now assigned at a very much higher initial salary than formerly.

Examination will undoubtedly be held during the latter part of June. Persons contemplating taking the examinations should write at once for information to the Department of Examinations, 828 Tribune Building, Chicago, Ill.

THE BIOLOGICAL STATION OF THE UNIVERSITY OF MICHIGAN.

By H. A. Gleason,
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In many respects the Biological Station of the University of Michigan differs radically from other stations of similar purpose in the United States. It is distinctly an out-of-door station, out in the woods, away from the railroad, away from all the distracting influences of urban or summer resort life. But it must not be considered that the place is entirely away from civilization. Mail comes out every day, there is a physician, a telephone, and an up-to-date mess-tent. The station embodies all the desirabilities of camp life and avoids all its discomforts.

The University of Michigan owns a tract of 1,666 acres of land adjoining the shore of Douglas Lake, in northern Michigan, and stretching across to Burt Lake, one of the largest inland bodies of water in the state. The University had previously maintained a summer camp for engineering students, giving them experience in surveying under conditions which can not be provided at Ann Arbor. Five years ago it was decided to move their camp to Douglas Lake, and the idea was conceived of locating a biological station at the same place. Some log buildings were already on the ground, which could be used for laboratories, and the engineers had established facilities for board, so that comparatively little difficulty or expense was encountered in preparing the site. The first session of the station was inaugurated in 1909, and since that time the thoroughness and value of the work have steadily improved. Both students and faculty have come to see the superiority of camp life over the ordinary sort of biological station. The faculty has discovered that the student does, at an average, twenty-five per cent more work than is done at the University in the same time, while the character of the work is such that it could not possibly be duplicated on the University campus. The student has discovered that he not only learns his science thoroughly, but that he also has a vacation, and returns to his regular work in the fall completely recreated. It is small wonder, then, that the same staff returns year after year, and that the average student spends two seasons at the station, while two of them have been there every one of the past four years.

Douglas Lake, on which the station is located, is only seventeen miles south of the Straits of Mackinac, so that the summer cli-

mate is delightfully cool. The lake is about four miles long by two and a half miles wide, and is surrounded on every side by rolling hills of sand or clay, covered generally with woods, and very sparsely settled. The margin of the lake is a gently sloping gravelly or sandy beach, with a maximum depth of three to eight feet of water. Beyond this shelf there is a sudden decline in the bottom, and in a very short distance the lake becomes forty to fifty feet deep, with a maximum depth of about eighty feet. The water is clear, and the great depth permits the study of the thermocline and other similar lacustrine phenomena. There are several small streams draining into the lake, but this combined volume is less than that of the outlet, indicating that there are also subaquatic springs. The outlet of the lake is through Maple River into Burt Lake. Although the latter is only a mile and a half from Douglas Lake, the river is over twenty miles long and follows a very circuitous course. There is a difference of one hundred feet in the level of the two lakes, and as a result a vast amount of subterranean drainage through the intervening sand ridges. The most remarkable feature of this is Big Springs, where a million gallons of water per day issue from numerous springs and form a trout stream flowing through a deep gorge to Burt Lake, a mile away.

Originally the native forests were composed chiefly of white and Norway pine, but these have long since been cut for lumber, and at present the prevailing forest growth on the cut-over land is oak, maple, birch, and aspen. More recently the hardwood forests have been cut, but there are still numerous tracts of beech, maple, and hemlock in virgin condition. There are also areas of considerable size covered with arbor-vitæ bog, and many small tamarack and sphagnum bogs. With such a variation in habitats, there is developed a luxuriant flora, and over five hundred and fifty species of flowering plants have been collected within walking distance of camp.

The station is located at the southeast end of the lake, six miles east of Pellston, eight miles northwest of Topinabee, and immediately on the state road from Pellston and Petoskey to Cheboygan. It is consequently easily accessible from either of two railroads.

The laboratory equipment consists of two log buildings, a tent laboratory, and an aquarium shelter. One of the log buildings, known as the "log laboratory," is used chiefly for class work. It is provided through the center with a series of shelves for ap-

paratus, with other shelves and book cases at either end, and with tables under the windows along the walls. On one side are four tables accommodating fourteen students, and at the other a single long table, used by investigators, and providing ample space for three. At the rear of this building is a lean-to, for the storage of collecting apparatus, nets, tools, and other bulky material, and with a photographic dark-room partitioned off in one corner. Near this laboratory is the aquarium shelter, with several aquaria and a large storage tank. The water is supplied by a windmill, with its intake in the lake. At the same place a substantial dock is built out to deep water, for convenience in using the boats and launches.

The other log building is called the "research laboratory." It contains likewise a set of shelves down the middle, and has three tables at each side near the windows. The building is used exclusively by the staff and research assistants. The tent laboratory is fitted in the same way, with central shelves and tables at the sides. These are assigned to advanced students or used for class work as occasion demands.

The University has provided generously for the equipment of the station, so that it now offers facilities for virtually every line of zoölogy and botany which are ordinarily followed at an inland station. Small articles, glassware, and reagents, are purchased directly by the station and stored there during the winter. Microscopes and other expensive articles are taken to the station from the university for each session. As indication of the equipment, some of its features may be mentioned. For transportation and collection, there are a 28-foot launch, a 16-foot launch, and several rowboats. For collecting, the station has a large number of fish nets, in various styles and sizes, plankton apparatus, dip nets, dredges, insect nets, traps, bird blinds, vasculums, and the like. For photography, there is an excellent box camera of the latest model, a reflecting Graflex with Tessar lens, and an apparatus for subaquatic photography. For the measurement of environmental conditions, there are thermometers of various patterns, evaporimeters, psychrometers, thermophones, photometers, rain-gauges, and soil-borers. For the preservation of specimens, there is a large supply of bottles, boxes, paper cartons, jars, presses and drying paper, insect boxes, stretching frames, and the like. For general convenience in conducting the affairs of the camp, a typewriter and a mimeograph have been provided.

Like the University of Michigan, the station is coeducational.

The women, under charge of the Dean of Women, occupy quarters at one side of the laboratories, and the men at the other. The tenting accommodations are uniform for both students and staff. Each tent is fourteen feet square, with three-foot wall, covered by a fly, and with a raised floor. The tent poles are permanent, insuring greater solidity than is possible with temporary poles. Each tent is fitted with one or two straw-filled bed ticks, covered with mosquito canopies, and is furnished with washstand, table, chairs, stove, lantern, and other utensils. The occupants furnish their own bedding and towels. Meals are taken at the mess tent, where they are prepared by professional cooks.

Classes are conducted in accordance with a regular program. To each class is assigned one or more whole days per week, giving thus the best opportunity for continuous work. Classes begin at seven-thirty, and continue with an intermission for dinner until late in the afternoon. After that the students' time is free. to be used either in recreation or in study as needed.

Instruction is provided in three courses in botany, forest botany, systematic botany, and ecology, and in four courses in zoölogy, invertebrate zoölogy, vertebrate zoölogy, ornithology, and entomology. Besides these regular courses, opportunity is offered advanced or graduate students to carry on investigation in either botany or zoölogy, under personal direction. Over half the students have been in the past wholly or partly engaged in research work. As an additional incentive to research, there are offered by the station each year research assistantships in both botany and zoölogy, which permit the holder to devote his time exclusively to research, without the payment of fees or the performance of any routine duties.

Out in the woods, six miles from town, and over two miles from the nearest house, the students must be provided not merely with work, but also with amusement. The station has apparently solved this necessity satisfactorily and with the proper division of time between the two. There is a regular hour for swimming every afternoon, and in the evening one laboratory is set aside for use as a recreation room. The boats are available for pleasure trips when not needed for scientific purposes, and there are frequent songs, bonfires, and marshmallow roasts along the beach. The regular hours, the abundant exercise, and the outdoor life make the students strong, and keep them healthy and happy.

The staff at the station has always considered that a field naturalist, whether botanist or zoölogist, should have some knowl-

edge of woodcraft, and be able to take care of himself properly when engaged in field work. So the students are encouraged to become skilful in setting up tents, in camp cooking, and in other similar features of camp life. These things of course are not compulsory. A camping trip, directed by an experienced woodsman, is sent out every Saturday, and every student is given a chance to go on one of them. Once each season, also, a four-day trip is taken around the neighboring shores of Lake Michigan and Lake Huron. Eight men make the trip, carrying all their supplies on their backs.

After four years experience, the value of the station is assured. The scientific opportunity is unquestioned; the opportunity for renewed physical health and vigor is undoubted. But probably more important than either of these, although less understood or appreciated by the student, is the chance given by eight weeks in the woods to get acquainted with one's self, and to view some of the affairs of life free from the bias of urban conventions.

TURPENTINE.

Turpentine from western yellow pine, says the Department of Agriculture, can be put to the same uses as that from the longleaf pine of the southeast, which furnishes the bulk of the turpentine of commerce. Western yellow pine forms enormous forests in the Rocky Mountain and Pacific Coast States, while the supply of longleaf is fast melting away. A product very similar to turpentine can be obtained also from pinon pine, another tree common in the southwest.

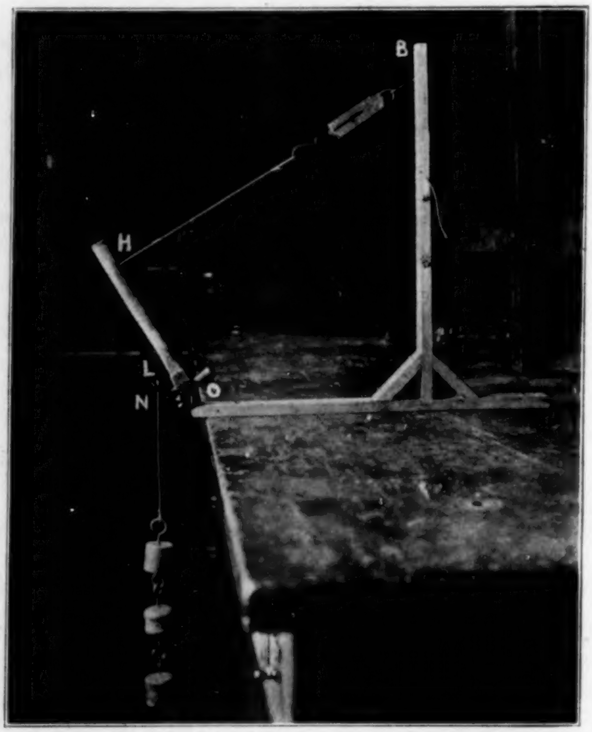
Careful tests made by the Department have shown that the yield of turpentine and rosin per season from western yellow pine in Arizona is only two-thirds that from the southeastern pine, the difference being due to fact that the season of flow in the west is about twenty-five weeks, and in the south about thirty-three weeks. During the Civil War, when turpentine operations in the south had virtually ceased, some operations were carried on in California to meet local needs. But with the return of the southern product to the California market, the western operations were abandoned.

The results of a chemical examination of the oils of western yellow, pinon, digger, sugar, and lodgepole pines which have just been published by the Forest Service in an official bulletin show the possibilities of the rosin and turpentine from western yellow and pinon pines as a supplement to the present supplies. Economic problems of markets, transportation, and labor remain to be solved. Information as to how the Forest Service secured the yields upon which the analyses were based is given in another bulletin on the possibilities of western pines as a source of naval stores.

EXPERIMENT TO SHOW THE PHYSICS OF A HAMMER DRAWING A NAIL.

By H. L. F. Morse,
Troy, N. Y.

The following idea was suggested to the Committee for Improvement of Laboratory Exercises in Physics of the New York State Science Teachers' Association. With some modifications, which we considered improvements, it was put into material form and tried out by the writer. The exercise created so much interest at the Syracuse meetings in December, that the Committee have already had several calls for blueprints and direction sheets. I think perhaps the idea may be of use to some of the live readers of School Science and Mathematics who are on the lookout for means and methods for putting a little animated stuff on to the dry bones of high school physics teaching.



For making the bracket only a suggestion or two is necessary beyond what the photograph and drawing show. It is quite apparent in Fig. 2 that the knife-edge on which the hammer head

rests is really a "chisel-edge" with the bevel side *in*. It is better to set this knife-edge at a slightly *obtuse angle* with the base of the bracket, so that in measuring ON and ON′ the end of the rule will be sure to press against the knife-edge *at* the point O and not *below* O.

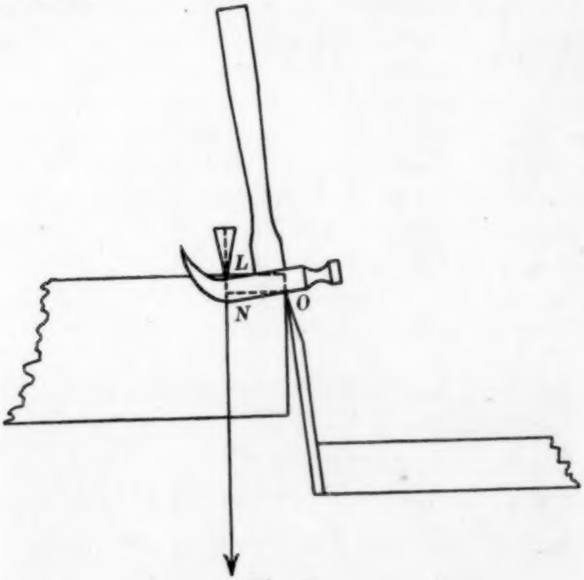


Fig. 2.

The upright piece of the bracket has holes one inch apart, through any one of which, the cord may pass, thus making the adjustment of the angle BHO to 90° a very easy matter.

In making the other knife-edge (see point L, Fig. 2) cut a piece of iron or brass about $1\frac{1}{2}$ by $\frac{1}{2}$ by $\frac{1}{8}$ inches. Then from the middle of one edge drill a 1-16 hole through the piece *edgewise* and afterwards grind down the faces to the wedge form. In doing this be sure that the "cutting line" of the knife-edge bisects exactly the circle of the 1-16 hole. A 1-16 wire inserted in the hole and headed on top completes this knife-edge.

At L and O on the hammer head are hack-saw cuts, not very deep, and made, of course, as nearly square across as possible. Any error however in making these cuts is taken care of by measuring ON and ON′ on the right and left sides of the hammer head. As we say in the direction sheet, a rule with a perfect zero reading should be used in making the ON measurements.

The point H on the hammer handle should be a small hole

drilled near the front side of the handle. Here again the measurements OH and OH′ take care of any error in drilling this hole. For variety one may have half a dozen of these holes if he wishes.

The direction sheets are complete enough, I think, in all other particulars. It goes without saying that the moments are: Col. 1 (corrected by Col. 3) multiplied by Col. 4, and Col. 2 multiplied by Col. 5. The point N is really the centre of the wire, but is more accurately measured as suggested in the note on the direction sheets. When the whole thing has been wrecked a few times, a fate it will certainly suffer, the wire will not be extremely straight and the exact location in space of the point N will become somewhat of a guess. And so if one cares for close results he will have to determine the values of ON and ON′ indirectly as suggested in the note.

There are blueprints and direction sheets to be had for the asking. We shall be glad to send them to anyone. Mr. J. A. Randall of Pratt Institute, Brooklyn, is Chairman of the New York State Committee.

DIRECTION SHEET.

Experiment: Application of moments to a hammer drawing a nail.

Apparatus: Bracket shown in drawing, hammer, spring balance, etc.

Procedure: Adjust cord so that angle BHO is very close to 90°. Complete Col. 1 of table by gently decreasing and increasing reading by finger applied at H. (Take four or six readings.)

Complete table as indicated by Col. headings.

Cautions: (1) Distance ON is as nearly horizontal as possible. (See note below.) (2) "Empty hammer," Col. 3, is obtained by removing load and reading balance. (3) Right and left values for Cols. 4 and 5 are obtained by measuring ON and ON′ and OH and OH′ on each side of the hammer head.

(Note: In measuring ON and ON′ a rule with a perfect zero reading, i. e., a square end from which to measure, is necessary. The end of the rule must be pressed against the knife-edge at O and the reading made on the upper edge from the knife-edge at L. That is, ON *cannot* be directly measured with accuracy sufficient for good results. (See Fig. 2.)

Spr. Bal. Reading	Load	Spr. Bal. Reading Empty Hammer	Distance OH & OH′	Distance ON & ON′
1	2	3	4	5

Discussion: Determine moment of force and moment of load by varying the methods of straight levers to apply to this case.

Conclusion: (As suggested by results).

THE ASTRONOMICAL TELESCOPE.

By Winthrop E. Fiske,
Phillips Exeter Academy, Exeter, N. H.

A diagram showing the action of the telescope is often given in elementary texts as in Fig. 1. Here AB is the object, MN the objective, A′B′ the real image cast by the objective, EE′ the eyepiece, A″B″ the virtual image seen through the eyepiece, II′ the observer's eye, F the principal focus of the objective, and F′ the principal focus of the eyepiece.

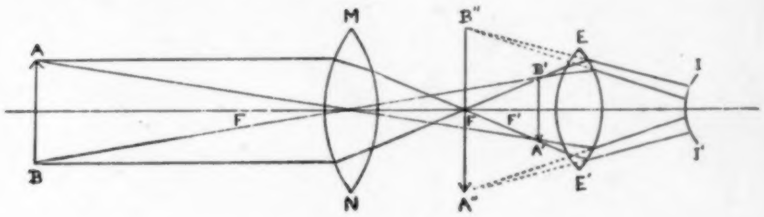


Fig. 1.

The image A′B′ is constructed as follows: Two rays are drawn from A, one to the center of curvature of the objective, the other parallel to the principal axis. The former ray emerges slightly displaced from its original direction, but parallel to it; the latter, after being refracted at both surfaces of the objective, passes through its principal focus. The crossing point of these two rays fixes the image point A′. B′ is similarly located.

In the construction of the virtual image A″B″ the rays already used are continued to the eyepiece, refracted at each of its surfaces, and finally bent toward the principal axis. Each pair is then produced backward, as shown by the dotted lines, until they cross at the points A″ and B″. Sometimes this image is represented as passing through F; there seems to be no special reason for this.

Now this diagram, while correct in the unusual case where the object is nearby, is clearly incorrect when AB is a distant object. For the image A′B′ will then lie, not beyond, but *at* the principal focus of the objective. This means that F must lie between F′ and the eyepiece.

The ordinary action of a telescope may be shown in Fig. 2, the same lettering being used as in Fig. 1. Here it must be understood that AB is a *distant* object, so that all rays from it to the objective are practically parallel, and are hence refracted to a region about

the principal focus. It is clear that A′B′ cannot be located as in Fig. 1. Furthermore, no attempt is made to show the relative sizes of AB and A′B′. All that can be said of A′B′ is that it is an inverted real image, smaller than its object, and located at the focal distance from the objective. It lies, of course, inside the focus of the eyepiece.

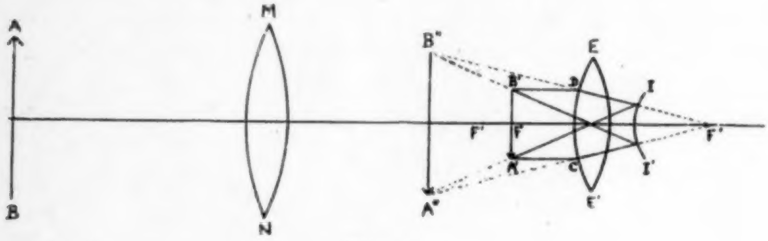


Fig. 2.

The virtual image A″B″ is located thus: A ray is drawn from A′ parallel to the principal axis, and from the point C, where it meets the eyepiece, is directed straight to F′, the focus on the other side of the eyepiece, the refraction when it emerges from the eyepiece being neglected. Another ray is drawn from A′ to the optical center of the eyepiece, and continued straight through, its lateral displacement being neglected. These two rays are produced backward until they cross at A″. The point B″ is similarly located. This method of locating an image is more practical for a student than either of those used in Fig. 1.

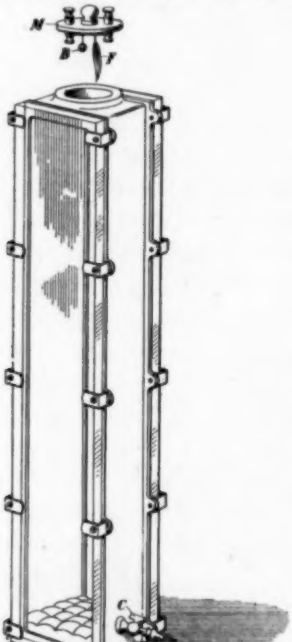
Of twenty-four texts in elementary physics examined by the writer six gave no diagrams for the telescope, seven gave correct ones, and eleven the incorrect one shown in Fig. 1. As some, at least, of these eleven texts are largely in use at the present time, it seemed advisable to call to the attention of teachers of physics this erratic treatment of a common optical instrument.

Assistant Professor William J. G. Land, of the Department of Botany in the University of Chicago, returned for regular work in the University at the opening of the Winter Quarter after an absence of four months in botanical investigations in Australia and the Samoan Islands. He spent two months in the island of Tutuila in the collection and study of plants, and was especially impressed by the remarkable growth and variety of the island ferns. Dr. Land also made observations in and around the crater of Kilauea in the Hawaiian Islands. He brought back a large amount of material for use by the Hull Botanical Laboratory.

THE PROJECTION OF "THE GUINEA AND THE FEATHER" EXPERIMENT.

By A. P. Carman,
University of Illinois.

The usual apparatus for "the guinea and the feather" experiment, to show all that all bodies fall with the same acceleration in a vacuum, consists of a glass tube three or four inches in diameter, with a coin and a feather inside. Upon inverting the exhausted tube quickly, those near by can see that the two objects fall somewhat together. The objects however often strike the sides of the



tube, and the observation is that the two objects "would" fall together *if* they fell freely. For a large class, the experiment is also unsatisfactory because most of the class see nothing. The experiment is so important in explaining "weight" and "mass," and has such historical importance that the writer and his assistants arranged apparatus so that the two objects are released at the same instant and fall freely, and so that a large class can see the occurrence by the direct shadow method of projection. The arrangement is simple, but it has been suggestive and useful to some who have seen it, and so it is described here.

An air-tight rectangular box of metal and glass was made, (Figure) forty inches long and with cross-section six inches square. The section could just as well be reduced to four inches square. The top, bottom and two of the opposite sides are of cast iron, the other two sides are of heavy plate glass cemented to the planed iron surfaces, and in addition held in place by clamps. A hose connection with stop-cock C is placed in one side for exhausting the air. There is a three inch circular opening in the top, and this is closed by a plane metal plate M, the fit of which is made air-tight by a flat rubber ring. Through this plate, there are insulated electrical binding posts and connectors, which carry on the under side a loop of small fuse wire. On this fuse wire are hung a feather F and a bullet B. These are released at the same instant by melting the fuse wire with an electric current. The box is placed in the light of the projection lantern, so that the shadows of the feather and bullet are distinct on the screen. When the objects are released by making the electric circuit, they fall, so far as the eye can tell, absolutely together, if the box is exhausted. The simultaneous fall can be seen clearly by everyone in the lecture room. An additional advantage of this apparatus is that it is separate from the air pump and is always ready.

ELECTION IN HIGH SCHOOL SCIENCE.

By Percy E. Rowell,
Berkeley, Cal.

The choice of high school sciences, on the part of many pupils, depends largely upon factors which are far from being educational. The reputation which the courses have acquired in a particular school, the opinon in which the science teachers are held, where there is a choice of teachers, as well as the fact that their friends are to take a certain course, or that the course comes at a convenient time, all have much greater weight in the minds of the pupils, when the year's work is being planned, than any consideration of the subject matter of any division of science, or its usefulness to them as preparation for future work. While the thoughtful teacher of science will agree with the above statement, he will nevertheless realize that the pupils are not to blame, for they have had no other basis for choice. The school is responsible. To choose wisely and well is a result of education. How then can a pupil be enabled to choose his education?

Dr. Eliot has said that the most important aim in education is to furnish opportunities for self-discovery. The study of a single division of science cannot furnish this opportunity. Therefore the science for the first year of high school should not be any one of the several divisions of science, from which the pupil must make his selection. The "choice" may be happy; in which case the pupil progresses. More likely it will be decidedly unfortunate, with the accompanying discouragement and probable failure. Nor is this all. A possibly great biologist may have been lost to the world by the choice of a natural science, or a successful engineer, in embryo, may have met his Waterloo in some biological science. On the other hand, many persons do not possess scientific tendencies which may be developed to any great extent, and the study of any single division of science, with its predestined failure, may cause the abandonment of all the divisions, which is a decided misfortune in this scientific age. Better a taste of all the branches of science than an absolute distaste for all.

While the chief aim of education is as Dr. Eliot has stated, it is necessary that this discovery of the self be as complete as possible. The pupil who learns considerable in one branch of science may discover himself to a greater or less extent. The discovery may be so great that he may consider himself sufficiently prepared for life. Even if the pupil remains in school the single science has been to a certain extent narrowing, as all early specialization must be. He thinks in terms of this one sicence. His mind will always use this science as a private measuring rod by which all science is to be gauged. Education should be broadening, not limited to subdivisions of topics. There is only only science. Man has made its divisions and raised each upon a pedestal; each with its worshippers.

Education should be self-perpetuating. It should make of every pupil an Oliver Twist, with his desire for "more." If the pupils feel that a course terminates at the end of the year they have suffered a great loss. This may be more dependent upon the teacher than upon the course, but surely no specialized course can ever have such a broadening influence and such a stimulating effect as a general course. Of all the general courses that may ever be given, that course which will touch the pupils' lives to the highest degree, and will have the greatest and most lasting, stimulating effect is a course in General Science.

The complete object of any course is to furnish facts, show

their relations to one another, create an appetite for more knowledge on the subject, and to develop in the pupil the power to acquire knowledge for himself—to teach him how to study. Too often we do all but the last. The better the teacher can *teach* the less the pupils study. Pupils are suffering from too much teaching. We need more instructors and fewer teachers in our schools. Then we would obtain a development of the pupils. Those courses are best in which the pupils do the most work. "Easy come, easy go" applies to education (?) as well as to one of the objects of education (without the question mark).

The question of how to get the pupils to work is a difficult one. It must be remembered that those who enter the high school, unless they have passed through an intermediate school, are not prepared in the methods of work which are necessary in high school courses. These methods must be taught. In this work the teachers are handicapped by the following considerations:

1. The pupils have firmly fixed in their minds that texts are supreme, and that the statements therein are final.
2. The texts have not been used as **texts,** but as sources of material. The guide has been raised to the status of the movement.
3. The pupils have been allowed to give **words,** in their oral and written work, rather than using the proper words to express their ideas.
4. The work has been made too easy for the pupils.

It is not the intention of this article to discuss the methods by which satisfactory results may be reached in all of the high school studies, but its purpose is to indicate that science work in the high school may be improved from the scientific standpoint, and also may do much toward teaching the pupils how to study, stimulating their ambition, and keeping them in school longer, if it is introduced in the first year by a course in General Science.

The material, the subject matter, for General Science, cannot be contained in one book. This is a blessing, still in disguise. Being forced during the year to seek information in at least ten books (the chief divisions of science), the pupils no longer consider one text as all-embracing. They also realize that *texts* may be elaborated into volumes—that the size of the book does not indicate the limits of the author's knowledge, but rather the extent of the publisher's daring. The discovery that the same idea may be expressed in many different ways is worth much more to them than the ability to repeat the words of any one book. They begin to weigh opinions and criticize statements. They work. They begin finding themselves.

The common and the everyday things are the really interesting ones. Dr. E. C. Moore has said that he did not expect to realize the ideal but there were hopes that the real might be idealized. The idea of a subject is what educates; not the repetition of words intended to express the idea. Words only too often are used to conceal the lack of ideas! There is more education in common things, if we can get the pupils to acquire the *idea*, than in the well prepared and nicely recited lessons concerning more abstract learning, when they are, after all, but *lessons* and not expressions of any real or lasting changes in the pupils' minds. And the idea of common things is the easiest to teach.

The order in which young people begin to "idealize the real" is of no consequence to them. The interest remains alive as long as the course is alive. Whether the future scientific training will be handicapped by an incorrect order of procedure in the elementary science is not a burning question. Scientific sequence was invented for teachers, by teachers. The classification of facts belongs in more advanced work. To understand facts and their bearing upon one another is more important than to be able to distinguish into just what artificial divisions of science the facts should be pigeonholed. Very often the classification is changed as knowledge increases. The only order which is valuable is one in which the unknown is grafted upon the known. This is not scientific sequence always, but it is the sequence of experience. In this case, surely, experience should be the teacher!

There are many ways in which General Science may be presented. Whether it is a clinging vine, depending upon some sturdy oak for support, or an independent sapling, requiring only heat, air, water, and food for its growing needs, remains to be seen. Its physical needs are apparent; its geographical requirements are few. Using the needs of every individual, in the order of their importance—heat, air, water, and food, a General Science course can be outlined which will include all that can be desired in the first year of high school science. It will be found that there is an excess of material, but this is an advantage, for in the necesssary selection the discrimination of both teacher and pupils may act, and discrimination is one phase of education.

The subject matter, as has been stated above, must be sought in several books, and the pupils do not know how to do this. They must learn. To know where to find information is one of the ambitions of the student (note that the word "student" is used advisedly), and one of the objects of our schools is to develop

students. Since General Science requires this knowledge it can become something more than science teaching; the pupils will learn more than the scientific facts. Of necessity there cannot be given much time to any one part of a General Science course. It must remain general, and it is not to be expected that the pupils will obtain a thorough knowledge of any one of its branches. That is the duty of the other more fully organized high school sciences. The object of General Science has been attained, as far as science goes, when the pupils are prepared to choose for themselves, and are eager to take up the work in some definite branch of science. The humanistic advantage of such a course cannot be overestimated. While it is not desirable to devote much time to any one part of such a general course, yet the whole course can be given a decided leaning toward any particular field of study. In an agricultural community argriculture, and the sciences which contribute to agriculture, can be emphasized; in a technical locality the different technical applications of science can be developed. Any line of work may have its beginnings in General Science. The great mass of the pupils, however, will gain the greatest good from the *general* character of the work, and those who leave school at the end of the first year of high school will carry with them a clearer outlook on the scientific world than they could have obtained from any one division of science.

After a course in General Science the pupils should have a double curriculum in science, from which they may make their choice. This means that there should be a biological and a natural science in each of the three succeeding years. There should be no restraint in the choice of sciences; both the biological and the natural sciences might be elected by some pupils in their second year, but the election would be real selection, and not based pon a passing whim or an idle fancy. The grade of work in these upper courses could be of a higher standard than is now possible, for the general methods of science would have been learned, and more attention could be given to the details of the special branch of science being studied.

The 100-inch reflector which has been on the polishing machine for several months in the workshops of the Mt. Wilson Observatory at Pasadena, Cal., are showing that the disk is probably useless, as was feared, and the completion of the great reflector seems therefore to be only a hope of the distant future, depending on the securing of a more perfect disk of glass.

SOME SUGGESTIONS CONCERNING EASILY OBTAINED PHYSIOGRAPHIC MATERIAL.

By Bernice L. Haug,
Detroit Central High School.

What ingredients shall the teacher use in the recipe for Physiography instruction, in order to evolve stupid Johnny into an alert and logical man? According to age and grade, the ingredients should vary, but in general they should consist of about equal parts of observation, problems, reading, and application of the principles to his own life and then to life in general.

To illustrate, why send him to a book to learn about weathering and erosion? The world is full of both. First, let him work out a definition of weather and then observe if he can find an object unaffected by this abused topic of conversation. The result is obvious. Let him now write out ten cases of weathered objects seen, stating the exact location of each, the effect of weather and telling whether the process is chemical or physical, i. e. whether it is like that which takes place when iron rusts, or when the sidewalk cracks. With these data in hand, the student can easily be led to see the origin of soil. In nine cases out of ten, some pupil will ask why the soil is so often in layers. Let him partially answer his question by the following simple experiment: Vigorously shake, in a bottle half full of water, a few teaspoonfuls of earth, taken from any locality where the soil is mixed sand and clay, and let the bottle stand till the water is clear. After the pupil has explained the temporary suspension of the material in the water and the deposition in layers, he should break the bottle and describe the sand and clay in detail.

Inquiries into the sticky nature of clay, its fitness for plant growth, the porosity of sand, the conservation of soil and his own dependence on soil, are apropos.

Following these independent observations, conducted field trips to quarries, deep excavations, sand pits, etc., are valuable. These localities furnish material for the study of the formation of the bed rock, varying depths and character of the soil, ground water, erosion, deposition, etc. If an unsodded area can be found and visited soon after a rain, the history of lakes, rivers, deltas, and sometimes terraces can be worked out.

For each field trip, a definite set of questions requiring a definite set of answers, should be given each student.

Now that the pupil has learned that weathering and erosion, in

some form, are every where (wherever there is weather), excursions to distant lands, by means of lantern slides, stereographs or common prints, are in order. Each scene should be discussed with reference to the special topographic form illustrated, the agent, and the process of formation.

Being now versed in the processes of land sculpture, the student is ready for a transcontinental journey by means of pictures and topographic maps. The preparation for the latter consists in the drawing of an outline map of the U. S., which shall include the states and the leading physical features, and the ability to interpret a contour map.

An easy method of acquiring the latter, is by the use of a model of a hill rising from a plain, made in horizontal layers (layers are the contour intervals). Let the student draw the layers on the board or on paper just as they exist in the model. He will then see the relation of contour lines to height and horizontal distance.

In this continental tour, the student familiarizes himself with great physical areas, each one of which, as soon as studied, should be outlined on the map (U. S.). Some of the most important side trips are to the Niagara Gorge, Mississippi flood plain and levees, lake plains and glacial formations.

A fitting conclusion to this sight seeing and studying, is to trace the influence of topographic forms on history. From a map of the earliest routes of travel, from Semple's Influence of Topography on American History, quite evident is the part played by rivers, water gaps and valleys. Topography made our victory in the Revolution possible, beckoned the center of population westward, and established Mason's and Dixon's line.

In connection with the natural resources, let the student study the relation between railroads, manufactures, agriculture and natural products. To be specific, let him study his own environment, to learn the reasons for the various occupations, imports, exports, the causes of the present progress or deterioration.

If time permits, inquire into the conditions of other nations, to determine the causes of their various ranks, the reasons for immigration and colonization and probable lines of future development. After even a little thought and investigation, the student agrees with Semple, when she says: "Man has been so noisy about the way he has 'conquered Nature,' and Nature has been so silent in her persistent influence over man, that the geographic factor in the equation of human development has been overlooked. . . .

Man can no more be scientifically studied apart from the ground which he tills, or the lands over which he travels, or the seas over which he trades, than polar bear or desert cactus can be understood apart from its habitat."

SCHOOL FARMING IN ALASKA.

The school-farm movement has penetrated Alaska. From the school at Klukwan, in Southern Alaska, comes a basket of potatoes, turnips, carrots, and other vegetables consigned to the United States Bureau of Education. Several of the products are of a size and weight that would be remarkable in a far more propitious climate than that of Alaska.

The school of Klukwan is one of 81 public schools for natives maintained by the Bureau of Education in Alaska. In a number of these gardening is carried on with distinct profit to the school and the community. The teacher from Shungnak, within the Arctic circle, reports that he supervised the making of 17 native gardens and four large school gardens. He instructed the school children and adults in soaking seed, planting, cutting potato eyes, spading, hoeing, raking, thinning, weeding, transplanting, watering—in fact, in all the operations necessary for successsful gardening. One-third of an acre he set apart as a model garden; on this he experimented with different products and eventually obtained a good supply of vegetables for use in cooking classes. Radishes, turnips, peas, rutabagas, carrots, beets, cabbages, potatoes, lettuce, kohl-rabi, parsnips, and a few other vegetables did well in this arctic garden; onions, beans, and cucumbers were unsuccessful.

At Eagle, Fort Yukon, Unalaska, and Klawock similar results in gardening are reported. In Unalaska the school farm at first contained only a few plats of rye and wheat, and some kitchen vegetables, but this year a more ambitious experiment was made. The children not only worked a school garden in which each had a patch of his own, but also cultivated a larger farm at some distance from the school.

Although the season is short in these Alaska settlements, the vegetables often attain good growth. In Klukwan the temperature ranges from 81 in summer to 27 below zero in winter. At Klawock the children were able to begin preparing their ground by the first of April, and elsewhere many of the vegetables were in by May.

The work in school gardening illustrates the general principle on which the government is working in the schools of Alaska—that education shall be something more than mere schooling; that it shall be preparation for the life the natives have to lead. Sewing, cooking, and carpentry are prominent subjects in the schools. "The education of the natives of Alaska," says a recent report of the Bureau of Education, "is conceived as meaning their advancement in civilization. Superintendents, teachers, physicians, and nurses must regard themselves as social workers striving to elevate the native races intellectually, morally, and physically."

EDUCATION NOTES.

The course in Spanish at the Naval Academy has been extended from two to four years.

Private benefactions for theological schools amounted to $1,680,000 during the past year.

An evening school for Boy Scouts has recently been established in the city of Leads, England.

State-aided industrial schools are now maintained in nineteen Massachusetts communities.

The Astronomic Society of Mexico will present a medal and diploma to every astronomer who discovers a comet.

A commission of teachers from Uruguay is studying educational institutions in the United States and Canada.

Nearly $1,000,000 is now on deposit in school savings banks in 1,149 schools throughout the United States.

Night schools of scientific agriculture are proving a popular feature with the farmers of western Michigan.

More than half the desks and tables in the primary schools of the Philippine Islands were made by the pupils themselves.

Illiteracy is practically banished in Prussia. Out of 165,841 army recruits in 1911, all but 24 could read and write.

Agricultural education will form an important section of the International Congress of Agriculture at Ghent, Belgium, in June.

The New York School Lunch Committee serves about 2,000 children a day with penny lunches in seven public schools in New York City.

The government of Uruguay has engaged an agricultural expert from the United States to organize an agricultural school in the Republic.

Austria's eight universities had 26,332 students last year, of whom 2,130 were women. The seven technical schools had 9,920 in attendance.

The Montessori method is to be tried by the normal schools of Ontario, Canada, following investigations of Montessori schools in the United States.

Over six hundred summer schools have announced sessions for 1913 according to the Educational Directory issued by the United States Bureau of Education.

Plans have been started by the Deutscher Verein at Columbia University for the organization of a union of German student societies in American universities.

The Syrian Protestant College at Beirut, Syria, has a commercial department that aims to fit its students for positions in the business houses of the Levant.

That instruction in domestic science be made compulsory for all girls' schools is urged in a petition signed by a large number of women in Berlin, Germany.

Sessions of the Newark, Ohio, high school are occasionally held at night, in order that the citizens may see at first hand the workings of their high school.

Virginia, Arkansas, and North Carolina now have "health almanacs" that are issued by the state board of health to popularize information on hygiene and sanitation.

Alaskan natives read American magazines. The United States Bureau of Education every year ships a number of current periodicals to the native schools.

Gloucester, Mass., has six parent-teacher associations formed within the past three years, all working to make a bond of co-operation between parents and the schools.

Lima, Peru, will be the meeting place of two important gatherings this summer—the sixth Pan-American Congress and the fifth Latin-American Medical Congress.

There were 1,445 farmers in attendance upon the "short course" at the Oregon Agricultural College this year, compared with 56 when the work was inaugurated six years ago.

The number of students in the high schools of Wisconsin who take Latin decreased twelve per cent during the past year, while the number of those taking German increased ten per cent.

The new compulsory continuation school for girls at Berlin will give six hours of instruction weekly, one-fourth of which must be given to courses dealing with "education for the home."

Of the million dollars spent by the city of Stockholm, Sweden, for its school system last year, $5,800 was for domestic science, $17,500 for school lunches, $5,400 for school physicians, and $2,400 for the dental clinic.

Three faculty representatives of the University of La Plata, Argentina, have been investigating educational methods in the United States. They are concerned chiefly with history, biology, and the rural-school problem.

Indiana boys failed in school more frequently than girls, according to a recent investigation of 14 Indiana cities by Superintendent Arthur Deamer, of Laporte. The percentage of failures was 14.6 for the boys and 10.4 for the girls.

A first year course in vocational guidance is offered in the high school at Highland Park, Ill. The purpose of the course is to aid students in selecting the subjects of the next three years with special reference to their life work.

The California State Legislature has adopted a resolution favoring Federal aid for industrial education and urging the establishment of a national university and a department of education at aWhsington with a secretary in the Cabinet.

Miss Margaret Wilson is directing a movement to interest the woman's clubs in urging social-center legislation in their respective states. The Russell Sage Foundation is co-operating with Miss Wilson and the Federated Women's Clubs in the work.

Ohio University announces a "quartet of new forces" in the State Normal College. The rural school and the Department of Agriculture are two of these forces upon which special emphasis is laid, since they represent a definite step in remedying the urgent problem of rural-school facilities.

Vocational work in high schools is now fully recognized with other subjects for admission to the University of Kansas. Three of the required fifteen units may be in manual training, domestic science, stenography, bookkeeping, agriculture, or commercial law. The University of Michigan also accepts vocational subjects.

Hookworm disease costs Arkansas more than one-fourth of its annual cotton crop, according to the Hon. George B. Cook, superintendent

of public instruction. Physicians and teachers are co-operating vigorously with the state board of health in their campaign for rural sanitation in that state.

Only men with practical experience in industry are allowed to enter the newly organized department for the training of teachers of manual arts in the Fitchburg, Mass., Normal School. It is planned to provide teachers of manual arts for the upper grades of the elementary schools and the high schools.

The Massachusetts board of education has a deputy commissioner for vocational education. His duties include supervision of State expenditures in aid of vocational schools; definitions of standards of instruction; approval of courses, teachers, etc.; and, in general, the enlightenment of public opinion on this form of education.

Nearly 2,000 titles in many languages make up the "Bibliography of the Teaching of Mathematics," by David Eugene Smith, of Teachers' College, Columbia University, and Charles Goldziher, of Budapest, Hungary. The bibliography has just been published for free distribution by the United States Bureau of Education.

The Kansas State Board of Health has issued a Health Almanac that is an important contribution to the campaign of health education. In form it is like the traditional almanac, but the hygienic advice it contains is clear, specific, and thoroughly up-to-date. It is patterned after the "Virginia Health Almanac" for 1911.

"The school authorities will lose a splendid opportunity if they continue to confine themselves to a bookish program and fail ot take a position of leadership in the great social movement now going on throughout the country," declares J. D. Eggleston, chief rural-school specialist of the United States Bureau of Education.

Harold W. Foght, of the United States Bureau of Education, is now in Denmark, studying rural schools with a view to adapting as much as possible of Danish experience to the American country-school problem. He is accompanied on the trip by William H. Smith, rural-school supervisor of Mississippi, and L. L. Friend, supervisor of high schools of West Virginia.

There are 635 colleges and universities listed by the United States Bureau of Education in the current Educational Directory. Ohio and Pennsylvania each have 42 institutions of college rank, and New York and Illinois 33. Missouri has 28, Iowa and Tennessee 27, Virginia 25, North Carolina 22, Indiana and Kentucky 21, Georgia 19, Kansas 19, and Massachusetts 18.

Dr. George Kerschensteiner, the German vocational expert, is impressed by the success of the American public schools in the task of assimilating immigrants. "What the great cities have been doing in transforming immigrants from all parts of the world into thinking citizens," he declares, "seems to me from my personal observations in the country itself to be unexampled in the history of education of civilized nations."

The Phelps-Stokes lectures on the negro problem given at the University of Virginia this year included the following subjects: Race relationships in the south; black-belt negro labor in slavery and freedom—its efficiency and its cost; the economic negro; the public-health relation of the race problem in the South. The aim of these lectures is "to arouse a scientific interest in the better adjustment of the negro to American civilization."

There are 101 teachers of agriculture in the normal schools of the United States, according to figures compiled by the United States Bureau of Education. Eighteen of them teach agriculture alone; 72 teach agriculture in combination with one or more sciences; nine teach two other subjects; and one three other subjects. One normal school-teacher handles agriculture in combination with the following: "Pedagogy, didactics, history of education, civics, child study, and school management."

The Buffalo, N. Y., Chamber of Commerce is leading in a movement to organize vocational training and vocational guidance in direct connection with the industrial, educational, and social needs of the city. Under the leadership of the chamber a committee composed of business men, school men, and social workers is making a preliminary survey of the city preparatory to mapping out a definite program. The work is under the immediate supervision of E. W. Weaver, vocational director of the Brooklyn Boys' High School.

Superintendent Joyner, of North Carolina, is making a strong plea for better educational facilities for that state. Among other things he urges that women be made eligible to serve on school boards, in order that the schools may have the benefit of their peculiar fitness for the work of education. He declares: "By nature and temperament, and because of their strategic position in the home and in the training of childhood, women are vitally concerned and deeply interested in the work of the schools."

The extent of the reindeer industry in Alaska under the United States Bureau of Education is indicated by the fact that it covers a territory as long as from Maine to South Carolina. If a line were drawn through the 54 herds it would stretch more than 5,000 miles. There are over 38,000 reindeer in these herds, two-thirds of them owned by natives. The value of the reindeer owned by the natives is estimated at $600,000, and from them during the past year was derived an income of $25,000 in addition to meat and hides consumed by the natives themselves.

Tennessee spent nearly twice as much money last year for high school purposes as the year before, and the actual number of high school buildings increased one-third. Other significant increases reported by the State high-school inspector are: Enrollmen, 46 per cent increase during the year; daily attendance, 47 per cent increase; length of average term, ten days more than the year before; and teachers, 65 per cent more. In the meantime the average cost of high-school tuition has been reduced from $4 to $3.96 per month.

A moving-picture film entitled "Tooth Ache" is one of the agencies employed by the National Mouth Hygiene Association to demonstrate the importance of instruction in the care of the teeth. Dr. W. G. Ebersole, of Cleveland, Ohio, who is secretary of the organization, says: "I believe that if each child be taught to keep thoroughly clean and healthy the gateway to his system, the mouth, we shall have a healthier, more self-respecting, and all-round better class of citizens for the next generation." It is believed that "Tooth Ache" will help develop public interest in oral hygiene.

Helping school officers in the hygienic features of their school-building problems is one of the occasional services performed by the United States Bureau of Education. Dr. F. B. Dresslar, chief of the division of school hygiene, with headquarters at Nashville, Tenn., has recently given assistance in preparing plans for school or college buildings in different sections of the country. Among these was a model consolidated schoolhouse to be erected on the grounds of the National Conservation

Exposition at Knoxville, and a proposed new building at Tuscaloosa, Ala., making use of open-air rooms.

The city of Breslau, Germany, has a new "school museum," where the best things in educational progress are shown for the benefit of the public. On the first floor are exhibits of school architecture, school furnishings, hygiene and statistics, mathematics, physics and chemistry, and a testing room for scientific aparatus used in the school. On the second floor are busts of well-known educators of the past—Comenius, Pestalozzi, Diesterweg, and Froebel; exhibits showing the teaching of religion, history, language, geography, astronomy, natural history and industrial economics, and the library. Above are the exhibits of manual training and domestic science; of auxiliary schools, kindergarten, and instruction of the blind; of drawing, singing, and physical training; and a large hall containing examples of school work from Germany and other lands. The Breslau school museum is one of fifteen permanent educational expositions established in the German Empire since 1904.

GOVERNMENT TIMBER.

The Government is selling 267,000,000 board feet of timber in the Priest River Valley of the Kaniksu National Forest, Idaho. This sale differs from most of those made by the Government in handling its National Forest timber business. Not only the ripe timber will be sold to make room ofr a new crop, but on part of the area the purchasers will be expected to take everything in sight, after the time-honored fashion of most lumbering that is done on private lands. In short, the forest will be destroyed.

In the Kaniksu sale part of the area will be clear-cut because the land is more valuable for agriculture than for forests. Stump land in the same neighborhood sells for as high as $40 or $50 an acre; sometimes even more. While the present stand of timber on the best land within the Forest is, according to the Forest Service, in general worth more than the land apart from the timber, the annual returns obtainable from farm crops make agriculture the best form of use for this land.

To open to homestead entry land with from $5,000 to $7,000 worth of timber on each homestead unit, as is the case on many homestead areas on the Kaniksu, tends to put a premium on its entry by timber speculators. From the speculators they go to lumber companies, and the lumber companies may hold back agricultural development either by keeping the timber intact for a long period, or by cutting the land clean and then holding it at a price which the prospective home-builder looking for cheap land to develop can not pay. Therefore the Government does not open to entry heavily timbered agricultural land on National Forests until after the timber has been cut off.

In this instance the Federal Government will receive about $650,000 for the timber, of which sum $225,000 will go to the benefit of the state for public schools and good roads, and the rest will be covered into the Treasury. All told, the yearly receipts from the National Forests have been about $2,000,000, of which timber sales have contributed about one-half, but the Forest Service reports that the demand for Government timber is now increasing rapidly. Since July 1 twice as much timber has been sold as was sold in the entire preceding twelve months, and while the timber will be paid for only as it is removed during a term of years the forestry officials expect to see the timber receipts mount up fast each year during the period immediately ahead.

PROBLEM DEPARTMENT.

By E. L. Brown,
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott Street, Denver, Colo.

Algebra.

328. *Proposed by A. Babbitt, State College, Pa.*

Solve:
$$\frac{b(x+y)}{x+y+cxy}+\frac{c(z+x)}{z+x+bzx}=a. \quad (1)$$

$$\frac{c(y+z)}{y+z+ayz}+\frac{a(x+y)}{x+y+cxy}=b. \quad (2)$$

$$\frac{a(z+x)}{z+x+bzx}+\frac{b(y+z)}{y+z+ayz}=c. \quad (3)$$

Solution by Nelson L. Roray, Metuchen, N. J.

(1) a—(2)b+(3)c gives

$$\frac{z+x}{z+x+bzx}=\frac{a^2+c^2-b^2}{2ac} \quad (4)$$

(1) a—(2)b—(3)c gives

$$\frac{y+z}{y+z+ayz}=\frac{c^2+b^2-a^2}{2bc} \quad (5)$$

Also
$$\frac{x+y}{x+y+cxy}=\frac{a^2+b^2-c^2}{2ab} \quad (6)$$

Dividing numerator and denominator of (4) by $z+x$, we get

$$\frac{1}{x}+\frac{1}{z}=\frac{b(a^2+c^2-b^2)}{4(s-a)(s-c)}$$

Similarly
$$\frac{1}{x}+\frac{1}{y}=\frac{c(a^2+b^2-c^2)}{4(s-a)(s-b)}$$

$$\frac{1}{y}+\frac{1}{z}=\frac{a(b^2+c^2-a^2)}{4(s-b)(s-c)}$$

Whence

$$x=\frac{8(s-a)(s-b)(s-c)}{b(s-b)(a^2+c^2-b^2)+c(s-c)(a^2+b^2-c^2)-a(s-a)(b^2+c^2-a^2)}$$

$$y=\frac{8(s-a)(s-b)(s-c)}{a(s-a)(c^2+b^2-a^2)-b(s-b)(a^2+c^2-b^2)+c(s-c)(a^2+b^2-c^2)}$$

$$z=\frac{8(s-a)(s-b)(s-c)}{a(s-a)(b^2+c^2-a^2)+b(s-b)(a^2+c^2-b^2)-c(s-c)(a^2+b^2-c^2)}$$

Note on problem No. 328.

If a, b and c are the sides of a triangle we obtain the following

$$\frac{1}{x}=\frac{2acb(s-b)\cos B}{8(s-a)(s-b)(s-c)}+\frac{2abc(s-c)\cos C}{8(s-a)(s-b)(s-c)}-\frac{2abc(s-a)\cos A}{8(s-a)(s-b)(s-c)}$$

$$=\frac{abcs(s-b)\cos B}{4\Delta\cdot\Delta}+\frac{abcs(s-c)\cos C}{4\Delta\cdot\Delta}-\frac{abcs(s-a)\cos A}{4\Delta\cdot\Delta}$$

$$=\frac{Rs\cos B}{r_2}+\frac{Rs\cos C}{r_3}-\frac{Rs\cos A}{r_1}$$

$$=Rs\left(\frac{\cos B}{r_2}+\frac{\cos C}{r_3}-\frac{\cos A}{r_1}\right)$$

Where R = radius of circum circle

r_1 = radius of escribed circle within $\angle A$

Or $\frac{1}{x}=\frac{R}{r}\left[(s-b)\cos B+(s-c)\cos C-(s-a)\cos A\right]$

Where r = radius of inscribed circle.

Also similar results for $\frac{1}{y}$ and $\frac{1}{z}$.

What are x, y and z as connected with the triangle?

329. *Proposed by H. E. Trefethen, Waterville, Maine.*

Find the condition that $x^3-3px+2q$ may be divisible by $(x-c)^2$.

Solutions by T. M. Blakslee, Ames, Iowa.

I. If the third root be d, by law of coefficients we have $2c+d=0$, $c^2+2cd=-3p$, $c^2d=-2q$ $\therefore$ $p=c^2$, $q=c^3$ and $p^3=q^2=c^6$.

II. As c is twice a root, if we substitute c by Horner's method the first two "remainders" each equal zero.

$\therefore$ $c^3-3cp+2q=0$ and $3c^2-3p=0$ $\therefore$ $p=c^2$, $q=c^3$ and $p^3=q^2$.

III. As c is twice a root of $F(x)=0$, it is once a root of $F'(x)=0$, giving the same equations as in II.

IV. The usual condition given in college algebra that $x^3+3Hx+G=0$ has two equal roots is $G^2-4H^3=0$, as before, we get $p^3=q^2$.

Geometry.

330. *Selected.*

The sides of a triangle are respectively x^2+x+1, $2x+1$, and x^2-1. Find the angle opposite the side x^2+x+1.

Solved by Otto J. Ramler, Buffalo, N. Y.

Let the projection of side $2x+1$ upon side x^2-1 be $\pm b$, where $+b$ will be the projection if the required angle is obtuse and $-b$ will be the projection if the required angle is acute. Then by a familiar proposition of geometry,

$$(x^2+x+1)^2=(2x+1)^2+(x^2-1)^2\pm2b(x^2-1),$$

whence $\pm b=\dfrac{(x^2+x+1)^2-(2x+1)^2-(x^2-1)^2}{2(x^2-1)}$

Simplifying, we have,

$$\pm b=\frac{2x+1}{2};\text{ hence, since }\frac{2x+1}{2}$$

must be plus, the required angle is obtuse.

Since the projection of side $2x+1$ upon x^2-1 is one-half of $2x+1$, the angle between $2x+1$ and x^2-1, must be 120°.

Hence the required angle is 120°.

331. *Prosposed by E. M. Dow, Brighton, Mass.*

In the quadrilateral ABEF the angles B and E are right and the diagonals BF and EA equal 60 and 40 respectively. The distance from D, the point of intersection of the diagonals, to BE is 15. Find length of BE.

Solution by Walter C. Eells, Tacoma, Wash., and Julia M. Bligh, Batavia, N. Y.

From D draw DM perpendicular to BE and DN perpendicular to EF.

Let $AB = c$, $BE = a$, $EF = b$, $DN = k$, $DM = 15$.

From right triangles

$$a^2+c^2 = 1600,$$
$$a^2+b^2 = 3600.$$
$$\therefore\ b^2 = 2000+c^2. \tag{1}$$

From similar triangles

$$b/a = 15/(a-k),$$
$$a/c = k/15.$$
$$\therefore\ b = 15c/(c-15) \tag{2}$$

From (1) and (2)

$$c^4-30c^3+2{,}000c^2-60{,}000c+450{,}000 = 0.$$

By Sturm's theorem this equation has only two real roots, one between 0 and 15, the other between 20 and 30. Clearly $c>15$.

By Horner's method we find the other root to be 21.5 approximately.

$\therefore$ Since $a^2 = 1600-\overline{21.5}^2$ $\therefore\ a = 33.73$ feet.

332. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

A room 20 feet by 15 feet, rectangular in shape, has a strip of carpet 2 feet wide placed diagonally so that each of the four corners touch one of the sides of the room. If the carpet is also rectangular, what is its length.

I. *Solution by T. M. Blakslee, Ames, Iowa.*

A diagonal of the room forms a right triangle having its sides including the right angle in the ratio $3x : 4x$.

$\therefore$ the hypotenuse is $5x$. The right triangle having one corner of the room as its right angle and the width of the carpet as its hypotenuse is similar to this; therefore its sides and hypotenuse are $3y$, $4y$ and $5y$.

The length of the carpet is less than the diagonal of the room by twice the altitude on its hypotenuse of the "y triangle." This altitude is a mean proportional between the segments of the hypotenuse. The sum of these segments is 24 inches; their ratio is 9 : 16, or they are $9z$ and $16z$, where $25z = 24$ inches. Their mean is $12z$, and twice the altitude is $24z = 23.04$ inches.

$\therefore$ length of carpet $= 23.1+$ feet.

II. *Solution by Levi S. Shively, Mount Morris, Ill., and Elmer Schuyler, Brooklyn, N. Y.*

Let ABCD be the rectangular floor with $AB = 20$ and $AD = 15$.

Let the carpet touch the side AB at F, AD at G, CD at H and BC at J. Let $x = AG$. Then Δ AGF is similar to Δ DGH; also Δ AGF is equal to ΔHJC.

$$\therefore\ \frac{x}{\sqrt{4-x^2}} = \frac{20-\sqrt{4-x^2}}{15-x}.$$

Rationalizing and reducing we have

$$4x^4-60x^3+609x^2+120x-1584 = 0.$$

It is geometrically evident that one of the roots of this equation lies between 0 and 2. By Horner's method this root is found to be 1.630+, $\therefore$ AF = CH = 1.158 and DH = 18.842.

If GH = y, the length of the carpet, we have

$1.63 : 2 = 18.842 : y. \therefore y = 23.103.$

III. *Solution by Wm. W. Johnson, Cleveland, Ohio.*

Let ADA_1D_1 be the rectangular floor with the length $AD = A_1D_1 = p$ and the width $AD_1 = A_1D = q$.

Let m = width of carpet, x = length of carpet, and $\angle C_1BD = \angle ACB = \theta$.

$AB = m\sin\theta$, $BD = x\cos\theta$ and $AB+BD = p$.

Then, $m\sin\theta+x\cos\theta = p$. (1)

$AC = m\cos\theta$, $CD_1 = DC_1 = x\sin\theta$ and $AC+CD_1 = q$.

Then, $x\sin\theta+m\cos\theta = q$. (2)

Solving (1) and (2) for $\sin\theta$ and $\cos\theta$, we get

$$\sin\theta = \frac{pm-qx}{m^2-x^2}, \text{ and } \cos\theta = \frac{qm-px}{m^2-x^2}.$$

Squaring, adding and putting $\sin^2\theta+\cos^2\theta = 1$, we get

$$\left[\frac{pm-qx}{m^2-x^2}\right]^2 + \left[\frac{qm-px}{m^2-x^2}\right]^2 = 1.$$

Expanding and clearing of fractions, gives

$$p^2m^2-2pmqx+q^2x^2+q^2m^2-2pmqx+p^2x^2 = m^4-2m^2x^2+x^4.$$

Combining and arranging according to the ascending powers of x, we have

$$x^4-(2m^2+p^2+q^2)x^2+4pmqx+(m^4-p^2m^2-q^2m^2) = 0.$$

or

$$x^4-(p^2+q^2+2m^2)x^2+4pmqx-m^2(p^2+q^2-m^2) = 0.$$

Putting, $p = 20$, $q = 15$, and $m = 2$, we get

$$x^4-633x^2+2400x-2484 = 0.$$

Solving this equation by Horner's method, we get

$$x = 23.10354 \text{ feet, or } 23 \text{ feet } 1\tfrac{1}{4} \text{ inches, nearly.}$$

Trigonometry.

333. *Proposed by Nelson L. Roray, Metuchen, N. J.*

If $a^4+b^4+c^4 = 2c^2(a^2+b^2)$, find value of angle C. (Hall & Knight's *Elementary Trigonometry.*)

I. *Solution by R. M. Mathews, Riverside, Cal., and H. H. Seidell, St. Louis, Mo.*

The Law of Cosines gives

$$\text{Cos C} = \frac{a^2+b^2-c^2}{2ab}.$$

From the given relation between a, b and c, we obtain

$$c^2 = a^2+b^2\pm ab\sqrt{2}$$

Substituting and reducing we find

$$\text{Cos } C = \pm\tfrac{1}{2}\sqrt{2}.$$

$$\therefore C = n\pi \pm \frac{\pi}{4}.$$

II. *Solution by Norman Anning, North Bend, B. C.*

$$\Delta = \tfrac{1}{2}ab \sin C = [s(s-a)(s-b)(s-c)]^{\frac{1}{2}}$$

$$= \tfrac{1}{4}(2b^2c^2+2c^2a^2+2a^2b^2-a^4-b^4-c^4)^{\frac{1}{2}}$$

$$= \pm\frac{ab\sqrt{2}}{4} \text{ when } 2c^2a^2+2b^2c^2 = a^4+b^4+c^4.$$

Hence $\sin C = \pm\frac{1}{2}\sqrt{2}$.

$C = 45°$ is the single solution.

CREDIT FOR SOLUTIONS.

312, 315. W. W. Gorsline. (2)
323, 324. Norman Anning. (2)
323, 324. F. Eugene Seymour. (2)
322. T. M. Blakslee. (1)
321. Nelson L. Roray. (1)
325. Oscar J. Jordan. (1)
328. Norman Anning, A. Babbitt, Julia M. Bligh, Nelson L. Roray, F. Eugene Seymour, Elmer Schuyler. (6)
329. Norman Anning, T. M. Blakslee (5 solutions), Julia M. Bligh (2 solutions), Walter C. Eells, A. M. Harding, A. L. McCarty, H. C. McMillin, Otto J. Ramler, W. J. Risley, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, Levi S. Shively, A. L. Womack. (19)
330. Norman Anning, T. M. Blakslee, Julia M. Bligh (2 solutions), Howard Carson, Arthur Collins, Walter C. Eells, John M. Gallagher, A. M. Harding, R. M. Mathews, Otto J. Ramler, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, F. Eugene Seymour, Levi S. Shively. (16)
331. Norman Anning, Julia M. Bligh, Walter C. Eells. (3)
332. T. M. Blakslee, Julia M. Bligh, Walter C. Eells, W. W. Johnson, H. C. McMillin, Nelson L. Roray, Elmer Schuyler, Levi S. Shively. (8)
333. Norman Anning, T. M. Blakslee, Julia M. Bligh, Howard Carson, Arthur Collins, Nelson L. Roray, Walter C. Eells, Agnes Mac Neish, R. M. Mathews, M. A. Plumb, Otto J. Ramler, W. J. Risley, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, Levi S. Shively. (16)

Total number of solutions, 77.

PROBLEMS FOR SOLUTION.

Algebra.

345. *From Hawke's Advanced Algebra, p. 136, Ex. 35.*

In an A. P. where a is the first term and s is the sum of the first n terms, find the expression for the sum of the first m terms.

346. *Proposed by Norman Anning, North Bend, B. C.*

Express $(a^2+mab+nb^2)(c^2+mcd+nd^2)$ in two ways in the form $X^2+mXY+nY^2$.

Geometry.

347. *Proposed by H. E. Trefethen, Waterville, Maine.*

O is a point in a given triangle ABC; x, y, z are the perpendiculars from O on the sides a, b, c respectively. When $x : y : z = a : b : c$,

(1) Find x, y, z in terms of the sides;

(2) Prove that the lines AO, BO, CO (produced) divide each the opposite side into segments proportional to the squares of the adjacent sides;

(3) Prove that $x^2+y^2+z^2 =$ minimum.

348. *Proposed by A. G. Bowne, Cedar Rapids, Iowa.*

If equilateral triangles be described (outward) on the sides of any triangle: (1) the lines joining the vertices of the original triangle to the opposite vertices of the equilateral triangles are concurrent; (2) the circles described about the equilateral triangles are concurrent; (3) the centers of these circum-circles form another equilateral triangle.

349. *Selected.*

If upon the base BC of a triangle two equilateral triangles BCE, BCE′ be described on opposite sides, and their vertices E, E′ be joined to A, then (1) if Δ denote the area of ABC, $AE^2-AE'^2 = 4\Delta\sqrt{3}$; (2) $AE^2+AE'^2 = AB^2+BC^2+CA^2$.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

105. *From Warren's "Elements of Agriculture," p. 384.*

How much more time will it take to raise 10 acres of corn on a field one-half mile from the buildings than to raise an equal area adjacent to the buildings? How much more would the nearer land be worth per acre?

106. *Proposed by E. Carl Watson, Brazil, Ind.*

400 gm. of mercury are heated to 71° C. and dropped into 200 gm. of water at 20° C. In the copper beaker which weighs 100 gm. are also a 30 gm. ball of steel and a 20 gm. ball of brass. The temperature of the water, etc, is raised to 23° C. From these data what is the specific heat of mercury?

PHYSICS. (Yale College, June, 1912.)

[Time allowed, one hour and a quarter.]

[One question may be omitted.]

1. Define *work, energy, power*. Cite an example of kinetic energy. What determines its magnitude? How could this energy be converted into heat? What is the source of the energy of an electric charge obtained by induction, as in the case of the electrophorus?

2. Briefly outline Torricelli's experiment on atmospheric pressure. How was his inference confirmed? To what important instrument has this experiment given rise? Explain the action of a siphon and mention any actual use of a siphon with which you may be familiar.

3. What is a vapor? Define *dew point*. What conditions facilitate evaporation? Explain why. Explain the cooling effect of evaporation.

4. What is the nature of light? Cite any experimental facts which tend to confirm the theory. Why does a stick, when partially submerged in water, appear to be bent? By a diagram, illustrate this apparent bending and explain it.

5. By aid of a diagram, explain the essential features of construction of a galvanometer, e. g., d'Arsonval. Discuss the fundamental principle of the instrument. How, in general, may the sensitiveness of a galvanometer be increased?

6. By aid of a diagram, illustrate the essential features of construction of a dynamo, and explain the action of each part.

CHEMISTRY.

[Time allowed, one hour and a quarter.]

Express by symbols all reactions.

[Ag=108, Ba=137, Cl=35.5, N=14, O=16.]

1. Describe, with reactions, two methods for preparing hydrogen. Sketch the necessary apparatus.

2. Give experimental proof of the presence in air of its chief constituents.

3. (*a*) Explain the following equations:

$$Zn+CuSO_4 = Cu+ZnSO_4$$

$$Cu+Ag_2SO_4 = Ag_2+CuSO_4$$

(*b*) Which pair of the three metals indicated will make the strongest voltaic couple?

4. Show by equations all reactions between carbonic acid and calcium hydroxide.

5. Explain by equations, (*a*) the action of hydrochloric acid upon iron, and (*b*) the action of chlorine on the compound produced in (*a*).

6. Show how the oxides of nitrogen (N_2O, NO, N_2O_3, N_2O_4, N_2O_5) illustrate the laws of definite and multiple proportions.

7. (*a*) Name and describe the substances indicated by the following symbols: H_2S, PbS, FeS, FeS_2.

(*b*) Show by reactions the preparation of ammonium sulphide, zinc sulphide, copper sulphide, and arsenic trisulphide.

8. Given the reaction,

$$2AgNO_3+BaCl_2 = 2AgCl+Ba(NO_3)_2,$$

calculate (*a*) the weight of silver chloride which may be formed from 5 grm. of barium chloride, and (*b*) the weight of silver contained in the silver chloride.

Solutions and Answers.

101. *Proposed by H. M. Swift, Mitchell, S. D.*

Is there any text published which gives a Physics course specially adapted to a class of high school girls? If not, is there any magazine article or other source from which one can obtain a reasonably detailed outline of such a course?

Answer by Franklin T. Jones.

As far as I know there is no text book in Physics written especially for girls. A number of text books, however, are easily adaptable to such a course—for instance D. E. Jones' "Heat, Light and Sound" (The Macmillan Company). A course for girls from this text was given at Laurel School, Cleveland, with great success and popularity. Unfortunately for science, the teacher has now confined her teaching to the more limited sphere of her own home. Many text books in current use may be suc-

cessfully used with girls by teaching only Heat, Light and Sound with portions of Electricity.

In "SCHOOL SCIENCE AND MATHEMATICS" a number of articles have been published bearing on this subject among them being: "Physics for Girls," by Willard N. Pyle, (sometime in 1910); "Physics in Segregated Classes," by Willis E. Tower, p. 1, 1911 and p. 19, 1912; "Adaptation of Physics to Different Types of Pupils," by S. E. Coleman, p. 131, 1912; "Practical Physics in Private Schools for Girls," by Elizabeth Duval Littell, p, 673, 1912. "Bibliography of Science Teaching," by W L. Eikenberry, pp. 567, 647, 1912.

102. *Proposed by H. M. Swift, Mitchell, S. D.*

It is reported that gasoline automobile motors will give more power on cold days than on warm days. If that belief is well founded, what is the explanation?

Answer from interview with C. P. Cary, Peerless Motor Car Co., Cleveland, Ohio.

This question can not be satisfactorily answered without limiting the conditions. The power derived from a gasoline motor depends on the number of B. T. U.'s available as power from the combustion, *i. e.*, upon the completeness of the combustion and upon the perfection of the mixture.

It is usually true in practice, that a motor will run steadier at night than in the day time. If in day time the machine is running properly, developing a certain horse power, it may lack power on hills. The same machine at night under precisely the same conditions will probably take the same hills with a steady "purr."

It is a question of getting the right relation between mechanical balance and power torque.

In winter time a carburetor has to be adjusted for more gas and less air. The temperature in the cylinder is lower, the gasoline does not vaporize as perfectly and a richer mixture is required to give the same available energy. In general the efficiency of a motor is lower in winter than in summer.

103. *Proposed by C. E. Guffin, Cleveland, Ohio.*

An elevator makes 30 round trips per hour. 36 seconds is allowed for stops on each trip. The distance traveled is 164 feet per round trip. The car is hoisted on a two part rope system which winds on a drum of 44" diameter geared to a motor which makes 425 R. P. M. What is the necessary gear reduction between motor and drum?

Answer by C. E. Guffin.

$\frac{30\text{x}36}{60} = 18$ minutes deducted for stops.

$60-18 = 42$ minutes net running time.

$164\text{x}2 = 328$ feet rope travel per round trip.

$\frac{328\text{x}30}{42} = 234$ feet per minute rope speed.

$\frac{234\text{x}12}{44\pi} = 20.35$ R. P. M. of drum.

$\frac{425}{20.35} = 20.85$ to 1 reduction. Ans

ARTICLES IN CURRENT PERIODICALS.

American Forestry for March; *1410 H. Street, N. W., Washington, D. C.; $2.00 per year; 20 cents a copy:* "Shade Trees; Their Selection and Care" (with twelve illustrations), F. A. Gaylord; "The Relation of the Forest Service to the Mining Industry" (with five illustrations), R. Y. Staurt; "The New Eastern National Forestry" (with six illustrations), Wm. L. Hall; "The States' Rights Question," Hon. John Lamb; "The Spread of the Forestry Movement," Dr. Henry S. Drinker.

American Naturalist for March; *Garrison, N. Y.; $4.00 per year, 40 cents a copy:* "Distribution and Species-forming of Ecto-parasites," Vernon L. Kellogg; "Castration in Relation to the Secondary Sexual Characters of Brown Leghorns," H. D. Goodale; "Simplification of Mendelian Formulæ," W. E. Castle. For April; "Alpheus Hyatt and His Principles of Research," Robert T. Jackson; "Bearing of Teratological Development in Nicotiana on Theories of Heredity," Orland E. White; Shorter Articles and Discussion: "Heredity in a Parthenogenetic Insect," James P. Kelly; "The Himalayan Rabbit Case, with Some Considerations on Multiple Allelomorphs," A. H. Sturtevant; "Mendelism and Interspecific Hybrids," Dr. O. F. Cook; "Ordovician (?) Fish Remains in Colorado," Professor T. D. A. Cockerell.

American Mathematical Monthly for February; *5548 Monroe Avenue, Chicago; $2.00 per year, 25 cents a copy:* "History of the Logarithmic and Exponential Concepts," Florian Cajori; "Minimum Courses in Engineering Mathematics," Saul Epiteen; "A Geometric Interpretation of the Function F in Hyperbolic Orbits," W. O. Beal. For March: "History of the Logarithmetic and Exponential Concepts," Florian Cajori; "Amicable Number Triples," L. E. Dickson; "Mathematical Literature for High Schools," G. A. Miller.

Catholic Educational Review for March; *Washington, D. C.; $3.00 per year 35c a copy:* "Feeling and Mental Development," Thomas E. Shields; "The Oldest and Latest Battlefield of the World," Francis P. Donnelly, S. J.; "Teachers' Professional Reading," Catherine R. O'Meara; "Survey of the Field—Sex Enlightenment," Thomas Edward Shields.

Educational Psychology for March; *Warwick and York, Baltimore, Md.; $1.50 per year, 20c a copy:* "The Problem of Formal Grammar in Elementary Education," Louis W. Rapeer; "The Sleep of School Children, its Distribution According to Age, and its Relation to Physical and Mental Efficiency. Part I. The Distribution of Sleep According to Age," Lewis M. Terman and Adeline Hocking; "Economical Learning," W. H. Pyle; "Value of Daily Drill in Arithmetic," F. M. Phillips.

Journal of Geography for April; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Dairying and Farming Industries in Canada," J. A. Ruddick; "Lumbering Industries of Canada," H. A. Heneyman; "Clay Belt of Northern Ontario and Quebec," John O. Daner; "Geographical Influence in the Location of Leading Canadian Cities," Isabel G. Britian; "Mineral Industries of Canada," H. C. Cooke; "Canadian Railway Development," J. J. O'Neill.

Mathematical Gazette for March; *G. Bell & Sons, Portugal St., Kingsway, London; 6 no., 9s. per year, 1s. 6d. a copy:* The Annual Meeting of the Mathematical Association: "Presidential Address: On Geometrical Constructions by Means of the Compass," Prof. E. W. Hobson; "Map Projections," E. M. Langley; "Intuition," G. St. L. Carson; "The Advisability of Including some Instruction in the School Course on the History of Mathematics," Miss M. E. Barwell; "The Teaching of Scholarship Mathematics in Secondary Schools," W. P. Milne; "Presidential Address to the London Branch," Prof. A. N. Whitehead; Reviews.

National Geographic Magazine for February; *Washington, D. C.; $2.50 per year, 25 cents a copy:* "Map of Central America, Cuba, Porto Rico, and the Islands of the Caribbean Sea" (11½ inches by 19 inches), Supplement; "The Recent Eruption of Katmai Volcano in Alaska" (with 57 illustrations), George C. Martin; "Do Volcanic Explosions Affect Our Climate?" (with illustrations), G. C. Abbot; "The Changing Map

in the Balkans" (with 27 illustrations and map), Frederick Moore; "The Countries of the Caribbean" (with 23 illustrations), William Joseph Showalter.

Nature-Study Review for March; *School of Education, University of Chicago; $1.00 per year, 15 cents a copy:* "The School Garden," Lewis M. Dougan; "Agriculture for Rural Schools," Arthur D. Cromwell; "The Small Crustaceans," W. C. Allee; "The Work of Running Water," Geo. J. Miller; "A Field Trip," Phyllis Gordon; "The Way of a Caterpillar," Ellen Robertson-Miller; "Hygiene as Nature Study," F. M. Gregg.

Photo Era for April;*383 Boylston St., Boston; $1.50 per year, 15 cents a copy:* "Systematic Photo Finishing," K. R. Bamford; "Daguerre and His Invention," James Thomson; "Comparison of Photo Costs," W. W. Klenke; "Selecting a Second-hand Camera," Verginia F. Clotlar; "Rebuilding a Camera," T. P. Frost.

Popular Astronomy for April; *Northfield, Minn.; $2.50 per year, 30 cents a copy:* "The Spectroscopic Determination of Stellar Velocities Considered Practically, with Plates VIII to XIV," Edwin B. Frost; "Experimental Proofs of the Earth's Rotation," William F. Rigge; "The Story of the Zodiac" (concluded), Edith R. Wilson.

The Popular Science Monthly for March; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* Henri Poincaré as an Investigator," James Byrnie Shaw; "A Chronicle of the Tribe of Corn," E. M. East; "The Utilization of the Nitrogen of the Air," Arthur A. Noyes; "The Laboratory Method and High-School Efficiency," Otis W. Caldwell; "How European Agriculture Is Financed," H. C. Price; "A Study in Jewish Psychopathology," J. G. Wilson; "The Language of Meterology," Charles F. Talman; "The Sweden Valley Ice Mine and its Explanation," Marlin O. Andrews; "What Becomes of the Light of the Stars," Frank W. Very. For April: "The Influence of Forests upon Climate," Robert DeC. Ward; "Goethe and the Chemists," Roy Temple House; "The Domestication of American Grapes," U. P. Hedrick; "United States Public Health Service," Alfred G. Reed; "The Increasing Mortality from Degenerative Maladies," E. E. Rittenhouse; "The Life Insurance Company as a Dynamic in the Movement for Physical Welfare," Eugene Lyman Fisk; "Natural Selection," T. D. A. Cockerell; "Some Random Thoughts concerning College Conditions," John J. Stevenson.

Physical Review for March; *Ithaca, N. Y.; $6.00 per year, 50 cents a copy:* "On the Theory of Relativity: Philosophical Aspects," R. D. Carmichael; "Change of Index of Refraction of Water with Change of Temperature," Frederick A. Osborn; "On the Electrical Nature of Cohesion," Fernando Sanford; "Brownian Movements in Gases at Low Pressures," R. A. Millikan; "Rectifying Properties of a Photo-Electric Cell," S. Herbert Anderson; "Ionization of Potassium Vapor by Ultra-Violet Light," S. H. Anderson.

Psychological Clinic for March; *Woodland Ave. and 36th Street, Philadelphia, Penn.; $1.50 per year 20 cents a copy:* "The Vitality of Teaching," W. Franklin Jones, Vermillion, S. D.; "Elimination from a Different Angle," G. W. Gayler, Canton, Ill.; Whistling at Work—A Crime?" Herbert F. Clark, Los Angeles, Cal.; "The Physical Status of the Special Class for Bright Children at the University of Pennsylvania, Summer Session of 1912," Harrison L. Harley.

School Review for April, *University of Chicago Press; $1.50 per year, 20 cents a copy:* "The Training of Secondary-School Teachers," C. B. Robertson; "A Home-Room Plan," James F. Barker; "The Six-Year High School," George Wheeler; "Living versus Dead Biology," Bertha May Clark; "Reliability of Grading Work in Mathematics," Daniel Starch and Edward C. Elliott.

School World for March; *Macmillan & Company, London, Eng.; 7s, 6d per year:* "The Ice Hath Taken Toll," B. C. W.; "Lord Haldane's Scheme of National Education," J. L. Paton; "School Books in Relation to Eyesight"; "The Reorganisation of Secondary Education in New South Wales," George Mackaness; "The Call of the 'Land'—in Association with

the Education and Training of the Unfit" (illustrated), Albert E. Lewis; "Needlework in a Secondary School" (with diagrams), Hilda M. Skinner; "The Historical Method in Science Teaching," W. D. Eggar; "The Value of the Historical Sequence in Teaching Chemistry," Thomas J. Kirkland.

Unterrichtsblätter für Mathematik und Naturwissenschaften, Nr. 1; Otto Salle, Berlin W 57, 8 No. M. 4, 60 pf. a copy: "Neue Versuche zur Elektrolyse," Prof. E. Grimsehl; "Diophantische Gleichungen zweiten Grades," Oberlehrer W. Kluge; "Bemerkungen über einen geometrischen Staz," Prof. Dr. A. Gutzmer; "Zum eukleidischen Beweis des pythagoreischen Lehrsatzes," M. Linnich.

Zeitschrift für den physikalischen und chemischen Unterricht for March; *Julius Springer, Berlin, W. 9 Link Sts. 23-24, 6 numbers, $2.88 M 12 per year:* "Ein Kapillarmanometer für Schülerübungen und Demonstrationsversuche," A. Wendler; "Die Umkehrung der Spektrallinien," E. Grimsehl; "Über die durch wiederholte Reflexionen innerhalb eines dreiseitigen Prismas erzeugten Bilder und eine neue Methode zur Bestimmung der Winkel eines Prismas mit nahe gleichseitigem Hauptschnitt," M. Byvoet und R. Sissingh; "Eine Methode zur Bestimmung des Brechungsverhältnisses einer Flüssigkeit," J. Oosting; "Stereoskopische Projektion in Unterrichte," H. Wlk; "Über Schreibstimmgabel, Schreibpendel und Schreibsaite," W. Büchel. Kleine Mitteilungen: "Ein Schülerübungsversuch über den freien Fall," F. Niemöller; "Gleichgewicht bei der Zentrifugalwage," Meinecke; "F. Laube, Eine einfache Zusammenstellung zur Demonstration der drahtlosen Telegraphie," Versuche mit einfachen Mitteln. Berichte: *1. Apparate und Versuche:* Die Molekularluftpumpe (W. Gaede).

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht, for February; *B. G. Teubner, Leipzig; 12 numbers, 12 Mark:* "Zur Kleinschen Einführung in die Lehre von den Logarithmen," Prof. C. Frenzel; "Zu den pythagoreischen Dreiecken," N. Gennimatás; "Ein mathematischer Scherz und seine didaktische Verwertung," H. Dressler; "Zur Behandlung der Zinseszins—und Rentenrechnung," F. Bindemann; "Ein bewegliches Polareckenmodell," Rud. Schimmack; "Zwei Dreiecksaufgaben," Prof. Kiesling; "Der Internationale Mathematikerkongress in Cambridge," W. Lietzmann; "Zur Geometrographie," edited by K. Hagge.

BIBLIOGRAPHY OF THE TEACHING OF MATHEMATICS.

The United States Bureau of Education has just published a *Bibliography of The Teaching of Mathematics* covering the period from 1900 to 1912, by David Eugene Smith and Charles Goldziher. This Bulletin gives 1849 titles of books and articles on the teaching of mathematics that have appeared since 1900. The Bulletin will be sent gratis upon application to the United States Commission of Education, Washington, D. C.

SEVEN STATES HAVE MOUNTAINS ABOVE 13,000 FEET.

There are three states which can boast of mountain peaks exceeding 14,000 feet in height above sea level, according to the United States Geological Survey. They are California, with Mount Whitney, 14,501 feet—the highest mountain in the United States, exclusive of Alaska—Colorado, with Mount Massive and Mount Elbert, each 14,402 feet; and Washington, with Mount Rainier, 14,363 feet. Wyoming, Utah, New Mexico, and Nevada all have mountain peaks exceeding 13,000 feet in height.

GERMAN PROSPERITY.

By Nicholas Knight,
Cornell College, Mount Vernon, Iowa.

Emperor William, Bismarck, and von Moltke, the great trio of the Nineteenth Century, were indeed sagacious and far-seeing statesmen, if they were able to look down through the years and to discern the prosperity which was to come to united Germany, following the Franco-Prussian war. This war cemented the German states into one great and powerful nation and deepened and quickened the intellectual life of the people. It greatly increased the efficiency of the universities and technical schools, as well as those of lower grade.

At any rate, whatever the causes, Germany occupies a pre-eminent position in learning, and especially in scientific achievements. The brightest and best from all lands seek the inspiration that comes from the association with the professors in the German schools. It is stated on competent authority that fifty-five per cent of all advanced scientific work and research is done on German territory, and all the rest of the civilized world has to content itself with the remaining forty-five per cent.

It would thus seem that the Germans are doing slightly more than their share, and yet the other great powers are leaving them in undisputed possession and undisputed masters of the field. The Germans are not narrow specialists and mere theorists, but they are in the fore-front in all applications of science. They not only have the science to apply, but they are most skillful and successful in applying it. They use their knowledge in agriculture, and the soil, instead of becoming worn out and exhausted, actually increases in productiveness from year to year. In their diversified manufacturing interests, their scientific attainments play a prominent part. And what a great manufacturing people they have become! The tall chimneys are everywhere in evidence, proclaiming in very emphatic language the high rank of the people in the industrial world. These factories are omnipresent in the towns and cities and in the rural districts as well; and in all places where the manufacturer has his problems to solve, he has on hand his trained scientists from the universities and technical schools, a small army in some industries, to study out the solution. Thus the schools and universities provide for every emergency in the industrial life of the nation, even as the Krupp Works supplied the modern guns with which the brilliant victories were gained in the war which resulted in German unity.

The prosperity of the nation is undoubtedly intertwined with the great activity of the people in scientific lines. This has not merely given the Fatherland a monopoly of the chemical and apparatus trade of the world. It has favorably affected every phase of their industrial and social development. Recent journeys through the empire from north to south through the large cities of the central portion, and from south to north through the western part, showed no evidence of poverty, but all the people seemed well employed and happy. Twenty years ago the inhabitants of the Black Forest boasted that they had no beggars within their territory, except some possible importations from the outside. The same happy conditions seem to prevail today throughout the whole empire. There is a great contrast between Germany and Italy, and even Anglo Saxon England suffers by comparison with her great Teutonic rival. The impression remains very persistently, that all things considered, Germany is possibly the foremost nation on earth today, and this in spite of a dearth of great natural resources. The country furnishes a notable example of the value of intensive scientific study in the solution of great national problems and in the working out of national destiny.

INDIVIDUAL LABORATORY WORK IN PHYSICS.

By Elmer J. Wilson,
High School, Fond du Lac, Wis.

After an experience of over ten years as teacher of physics, during which time I allowed pupils to work in groups of two or sometimes more, I determined last year to try the individual plan, *i. e.*, to have each pupil work entirely alone. I was led to try this plan because it did not seem to me that the group plan was entirely satisfactory for many reasons, a few of which I will state.

When two pupils work together, it is usually true that one of them is better prepared, more aggressive, or not as lazy as the other and hence does by far the larger share of the work and thinking, the other acting simply as a copyist. The confusion arising from necessary—to say nothing of the unnecessary communication—when pupils are allowed to work together is, it seems to me, detrimental to best work and progress. Pupils working together are apt, especially if there is a party, sleighride, or other amusement in anticipation—and when are these not in anticipation in the modern high school—to mix their experiments with their social affairs.

Since we had a new building in process of construction last year which we were planning equipment for, the time was ripe for any change as radical as having a table constructed for each pupil, which is what we finally did, after having the pupils do individual work at the large tables with which the old building was equipped in order to try the plan. The physics laboratory in the new building is a room about 24x32 feet in dimensions. It contains eighteen tables, each two feet wide, three and one-half feet long and thirty inches high, arranged with convenient aisles between. These tables are similar to library tables, in construction heavy and substantial. The legs are of oak 3x3 in., the top is built up of maple strips 1¾ in. thick, finished black. Each table is equipped with an ink well and two brass plates, one near each end, set flush with the table top tapped to receive ½ in. nickel plated support rods. The tables contain no iron or steel in their construction. Gas is obtained from a pipe extending along three sides of the room. When we wish to use gas we move the tables near the walls. Of course there is other equipment in the room, but since I am dealing with the individual phase of laboratory instruction, I will omit any further description and simply state results.

We had sixty-eight pupils taking physics last year and had them divided into two divisions for lecture and recitation purposes, and into four divisions of seventeen each for laboratory work. Each pupil had four single periods in the lecture room and one double period in the laboratory each week. It was, therefore, necessary to have seventeen sets of apparatus or else to have more than one experiment in progress at the same time. I have an average of about ten sets and have two or possibly three different experiments in progress. I find this no great disadvantage, for by keeping one-half of the pupils one experiment in advance of the other half, they all take the couse in logical sequence. To be sure it takes a little more equipment, but laboratory equipment is so inexpensive in comparison with the better results obtained that the additional expense is worthy of small consideration. It seems to me that it is our duty as educators to attempt to secure what some one has called a "mental wriggle" as often as possible, from our more lazy and inert pupils especially, and I am satisfied that I secure it much oftener when those pupils know that they must either do the work, solve the problems and answer the questions themselves, or secure necessary assistance from the instructor.

ELEMENTARY PHYSICS EXAMINATION.

By P. W. Dysart, Pittsburgh High School, B Class, June, 1912.

Time Limit, $3\frac{1}{2}$ hours.

1. Two tugboats pull upon the same ship, one N with a force of 1,000 pounds, the other E with a force of 500 pounds. Find the direction and force with which a single tugboat should pull in order to produce the same effect upon the ship as the two boats.

2. A small car having a mass of 500 g. and free to move without friction over a level surface is loaded with a kilogram mass. A force of 30,000 dynes acting towards the north is exerted upon a cord attached to the car. At what rate per second does the car gain velocity while it carries the mass? At what rate per second does it gain velocity after the mass has been removed?

3. Draw a section of a force pump illustrating the action while the piston is moving upward—not the first stroke—and a section illustrating the action while the piston is moving downward. The pump does not have an air-chamber.

4. The diameter of the barrel of a capstan is 18 inches, each of six sailors pushes upon a separate bar at a point that is distant 6 feet from the axis of the capstan. Each sailor pushes at right angles to his bar with a force of 50 pounds. A 2,000 pound anchor is raised by the winding of its rope around the drum of the capstan. What is the efficiency of this device? Make a sketch of the device.

5. (a) Find the length of the waves sent out into the air by a tuning fork making 300 vibrations per second, by one making 200 vibrations per second. The velocity of sound in the air is 345 m. per second. (b) How would the sensation produced by the waves from the second fork differ from that produced by the waves from the first fork?

6. (a) The bulb of an alcohol thermometer is exactly filled with alcohol at a temperature of 0° C. To what height in the tube, whose cross-sectional area is $2mm^2$ will the alcohol rise when its temperature becomes 20° C. The capacity of the bulb is $4{,}000\ mm^3$, the coefficient of volume expansion of the alcohol is .001. (b) State the factors, or circumstances, upon which the pressure of a vapor depends.

7. (a) A pressure gage connected with an inflated automobile tire reads 75 pounds per $inch^2$, when the temperature of the air in the tire is 27° C. What is the pressure—above the atmosphere—of the air in the tire when its temperature becomes 387° C.

7. (b) Describe an experiment or relate an experience illustrating the difference in conductivity of glass and of copper.

8. Draw two sections of a gas engine, one illustrating the explosion stroke, the other, the exhaust stroke. Label the parts of the engine.

9. A plane-fronted wave, 6 cm. broad, coming from the left, falls upon a double-convex crown glass lens whose chord is 4 cm., and whose radii are each 3 cm. Find by construction the effect of the lens upon the wave.

10. (a) A certain piece of paper, when illuminated by white light sends out violet, blue and green light only. What will it send out when illuminated by pure yellow light?

(b) Two projecting lanterns send light to the same part of a screen. From one of the lanterns violet, blue and green light are sent out, from the other yellow and red light; what color will the part of the screen illuminated by both lanterns appear to be?

11. (a) Draw a diagram showing the action of a copper-sulphuric-acid-zinc cell. State what are formed and what used up during the action. (b) State two undesirable effects of the presence of hydrogen gas upon the copper plate.

12. A generator of 120 volts e. m. f., and 2.0 ohms resistance, supplies thru leads of 3.0 ohms resistance, two incandescent lamps in parallel, A, of 300 ohms, B of 100 ohms resistance. Diagram the connections. Find the strength of the current flowing thru the generator, thru A, thru B, the potential difference of the terminals of A.

13. (a) Draw a section of an induction coil, label the parts, and sketch in lightly the magnetic field of the primary coil. (b) What conditions must be fulfilled in order that the secondary coil shall produce a very high electromotive force?

AN IMPROVED LABORATORY EXERCISE.

By Carl M. Kibler,
Harris High Shool, Petersburg, Ill.

Any one who has tried the method, described by Remsen, for finding the volumetric composition of ammonia gas by allowing a measured volume of chlorine to interact with ammonia, will welcome an improvement in the method of the experiment.

Instead of the closed tube usually used, which makes the admission of the ammonium hydroxide so difficult, an ordinary burette, such as used in titration, is needed. The upper part of a straight stemmed dropping funnel is connected with the stopcock end of the burette, by a short length of rubber tubing. With the stopcock closed, the burette is then filled with a saturated solution of sodium chloride, and inverted into a vessel of the salt solution. The tube is then filled with chlorine by introducing the gas into the submerged end. The length of the chlorine column is then carefully measured. After which, concentrated ammonium hydroxide is poured into the dropping funnel, and admitted into the chlorine tube by opening the stopcock very slightly. A slight flash, considerable heat, and white fumes indicate the chemical change. Ammonium hydroxide is added until the change seems complete. The excess ammonia is neutralized, as usual, by adding dilute sulphuric acid. Care should be taken during the opening of the stopcock that no air be allowed to enter the burette. When the gas has cooled to the room temperature, correction is made for the difference in level, and the length of the residual gas column is measured. Since the volume of a cylinder varies directly as the length, these measurements may be taken as the volumes of the gases. It is, of course, necessary that correction be made for pressure, temperature, and aqueous tension. This may be done by formula. Since chlorine unites with hydrogen, volume for volume, the values found above are the relative amounts of hydrogen and nitrogen in ammonia.

This improvement requires only the ordinary laboratory equipment, and it simplifies a difficult exercise quite materially. As may be seen from the following results, taken from the laboratory record of a member of one of the writer's present classes, the ratios obtained would seem to justify its use as a class exercise.

Ratios of hydrogen to nitrogen:

1st trial—1 : 2.79
2nd trial—1 : 3.129
3rd trial—1 : 3.09.

GOVERNMENT SHOULD HAVE JURISDICTION IN GLACIER NATIONAL PARK.

That the National Government accept the cession of jurisdiction over the area embraced within the park and that it acquire all private holdings in the reservation are the main recommendations contained in the annual report of the Acting Superintendent of the Glacier National Park, just made public by the Department of the Interior. "It would greatly added to the economical and advantageous adminstration of the park," says Acting Superintendent Chapman, "if the Government would acquire all private holdings within its boundaries at the earliest possible date."

Within the borders of the Glacier National Park are attractions for the scientist, nature lover, and tourist unsurpassed in any country in the world, tourists of world-wide experience pronouncing it the Switzerland of America. The elevations in the park range from 3,100 feet to over 10,400. Within its confines are 60 active glaciers, these ice sheets being the sources of beautiful cascades and roaring mountain streams flowing into innumerable, clear, placid lakes for which the park is famed, the most noted of these being Lake McDonald, Lake St. Marys, Lake Louise, Iceberg Lake, Red Eagle Lake, Kintla Lake, Bowman Lake, Waterton Lake, Logging Lake, Quartz Lake, Harrison Lake, and Two Medicine Lake. Lake McDonald, the southern end of which is 2½ miles from Belton, is one of the most beautiful lakes in America. It is about 3,150 feet above sea level, nearly 10 miles long, 2 miles wide, and surrounded by mountains covered with virgin forests of western larch, cedar, white pine, Douglas fir, spruce, and hemlock. Upper Lake St. Marys is on the eastern side of the mountains about 32 miles north of Midvale. It is about 10 miles long, with a maximum width of 1 mile, and toward the upper end the mountains rise in rugged walls not far from the water's edge. Its elevation is about 4,470 feet above sea level. The principal glaciers in the park are Blackfoot, Grinnell, Harrison, Pumpelly, Red Eagle, Sperry, Kintla, Agassiz, and Chaney. In most of the lakes of the park there is excellent fishing at certain times of the year, and at others many of the streams afford fine sport with hook and line. Within the park boundaries there are many varieties of game which are indigenous to this section of the country, such as bear, elk, moose, deer, big-horn sheep, mountain goat, mountain lion, as well as the smaller furred animals of the forest. On April 1, 1912, a carload of elk was received from the Yellowstone National Park and turned loose in the park at Belton, the western entrance.

SCHOOLS AS EMPLOYMENT BUREAUS.

Schoolhouses as employment offices is the most recent proposal in the movement for the wider use of the school plant, according to information received at the United States Bureau of Education. The use of schools as "social centers" has become familiar through the organized movement of the last year or two, and more recently the use of the school buildings as polling booths and forums for political discussion has become known through the example of New York and Chicago. Now comes Prof. John R. Commons, a member of the Wisconsin Industrial Commission, with a proposal to use the schoolhouse as a labor exchange.

The plan to link the social-center work with the economic problem of the unemployed is urged by Prof. Commons in the following

terms: "There is need of an organized market for labor * * * If each schoolhouse has a director of its social-center service, he could be supplied with blanks from a main employment office. A workman, by going to the school nearest his house to register, could be immediately connected wih the whole organized-labor market of the State."

Nor should this mark the end of the school's function in the labor problem, according to Prof. Commons. He believes that the school, acting as a branch of the children's department of the employment office, should be made to help reduce the maladjustment of occupations that is now a crying evil. "Records of children's aptitudes should be kept in school. Teachers can best tell what the child is good for; and they should direct the children into the most promising occupations." It should be said that this principle is already partially recognized by public authorities. The vocation bureau of the city of Boston aids in directing the future occupation of children in the schools. In Ohio the truant officer is required by a recent statute to keep on file a list of the children between the ages of 14 and 16 who have received school certificates and desire employment; prospective employers are to have access to this list.

The attention given to Prof. Commons' proposal emphasizes the rapid development of the idea of "wider use of the school plant," since Mr. Edward J. Ward inaugurated the social-center work at Rochester. Kansas City affords a current instance of the readiness to accept the social-center idea. The board of education of that city recently voted to open seventeen school buildings for neighborhood uses at night. School clubs will be organized for the discussion of civic and economic questions; there will be literary and dramatic clubs, sewing and camp-fire clubs. There will be lectures, moving pictures, folk dances, gymnastics, and all the other neighborhood activities that are necessary to wholesome community life.

The use of school buildings as forums for political discussion is now a fact in both Chicago and New York; in the latter city a plan to use the buildings as polling places received strong support from civic organizations; and while educators have no way of finding out just how far the suggestion of schoolhouses as labor exchanges will be adopted, the fact that a proposal like this receives attention proves how widespread is the sentiment in favor of any and all projects involving a wider use of the school plant for the benefit of the community.

BOOKS RECEIVED.

Physical Laboratory Guide, by Frederick C. Reeve, Academy, Newark, N. J. Pages x+182. 13x19 cm. Cloth. 1912. American Book Company, New York.

Solid Geometry by the Syllabus Method, by Eugene R. Smith, Park School, Baltimore, Maryland. Pages xi+211. 13x19 cm. Cloth. 1913. American Book Company, New York.

Seventh Annual Report of the Carnegie Foundation for the Advancement of Teaching, of the President and Treasurer. Pages vi+194. 19x26 cm. Paper. 1912. 576 Fifth Ave., New York City.

Hygiene for the Worker. By W. H. Tolman. 231 pages. Illustrated. 12 x 18 cm. 1912. American Book Company, New York.

Business Arithmetic for Secondary Schools. By Ernest L. Thurston,

Asst. Superintendent of School, Washington, D. C. Pages xiv+431. 13 x 19 cm. 1913. Cloth. $1.00, net. The Macmillan Company, New York.

Journal of Proceedings Fiftieth Annual Meeting National Education Association. Pages xii+1427. 16 x 23 cm. 1912. Cloth. Ann Arbor, Michigan.

College Entrance Requirements. Compiled by Clarence D. Kingsley. 110 pages. 15 x 23 cm. 1913. Paper. Government Printing Office, Washington.

Present Standards of Higher Education in the United States. By George E. MacLean. 191 pages. 15 x 23 cm. 1913. Paper. Government Printing Office, Washington.

Status of Rural Education in the United States. By A. C. Monohan. Pages 73. 15 x 23 cm. 1913. Paper. Government Printing Office, Washington.

Latin-American Universities and Special Schools. By Edgar E. Brandon. 153 pages. 15 x 23 cm. 1913. Paper. Government Printing Office, Washington.

BOOK REVIEWS.

Essentials of Electricity, Direct Currents, by W. H. Timbie, Wentworth Institute, Boston. Pages xiii + 271. 12 × 17 cm. 224 figures. Cloth. 1913. $1.25, net. John Wiley & Sons, New York.

This is a splendid book. Just the book for practical wiremen, secondary students in electricity, and for the person who wishes to keep in touch with the fundamentals of direct current electricity. For these people no better book has been written. It is a live wire from pole to pole. It abounds with helpful suggestions, its statements are clear and to the point, and is written so that the reader can understand it. There are not many descriptions of mechanical operations, but it is full of explanations of the fundamental principles of good electrical practice. It is a book worth while for the self-instructed to possess. It is of a convenient size to carry in one's pocket. The method of presentation is excellent, the reader is at once interested and instructed. The book is filled with a large number of the practical problems taken largely from actual practice. Teachers get the book and use it in your classes. You will make no mistake by so doing. C. H. S.

Essentials of Physics, by George A. Hill, Howard College. Pages viii + 344. 13 × 19 cm. Illustrated, 1912. Price, cloth, $1.10. Ginn & Company, Boston.

This is an unique and practical text. The subject matter is presented in a manner not often attempted. The author through his long experience as a physics teacher has arrived at the conclusion that the best way to present the subject to secondary school pupils is by the question and answer method. Therefore, this text is filled from cover to cover with questions, hundreds of them. First come answered questions, in which just enough of the theory is given for the pupil to grasp the idea under consideration, these being followed by questions for the pupil to answer, and problems for him to solve. The questions are arranged in a careful and logical sequence. Most of the illustrations are aptly chosen and well executed. The treatment of the subject is clear and to the point. There is nothing in the book to omit, the topics being well chosen.

The mechanical work is perfect, press work excellent, and the kind of type and its arrangement well selected. It is a book that will appeal to progressive teachers. C. H. S.

A Text-Book of Physics, by S. E. Coleman, High School, Oakland, Calif. Pages ix+658. 485 figures. 13 x 19 cm. Cloth, $1.25. D. C. Heath & Co., Chicago.

If one is not already familiar with this excellent text, the best way to become so is to send at once for a copy. Without fear of contradiction, the reviewer must say that it is one of the best texts for secondary school work in physics now published in this country. He is acquainted with them all and has tried out many of them in his classes, and this one has stood the test as well as any.

The subject matter is drawn very largely from the common surroundings in the affairs of the pupils' daily life. The treatment is such as to appeal to the reader's better instincts, creating in him a desire to know more of the subject. The arrangement of the matter is as logical as it is possible for a text in physics to be. It is written in a clear, concise and readable way. The statement of facts are clearly and correctly made. The author's long experience as a teacher has enabled him to put together a book which is as nearly perfect from a pedagogical and a physics point of view as is possible for one to do. Splendid lists of questions and problems are frequently given, which help to fasten the principles of physics firmly in the pupil's mind. Most of the cuts are new. There is a complete index. The mechanical work has been well done, making the book one which will stand hard usage. The type is large and clear and paper of finest quality. C. H. S.

A History of Chemistry, from the Earliest Times Till the Present Day, by the late James C. Brown, University of Liverpool. xxix+543 pages. 15x22 cm. Cloth. 1913. $3.50, net. P. Blakiston's Son & Co., Philadelphia.

This is a book which should be in the library of every one interested in chemistry. It discusses the history of the subject from the very earliest periods, and closes with matters of the present time. 192 pages are devoted to very ancient history. The work is a compilation of some of the lectures which the author delivered before his classes. It will be a helpful work for any chemistry teacher.

There are one hundred and six illustrations. The table of contents, too long to be given here, is a fine synopsis of the text. A very complete index is gixen. The book is well made, printed on an excellent quality of calendered paper, type large and words not set too closely together, an easy book to read and study. It represents a long life time of study and investigation, and is really an authority on the subject

C. H. S.

Mineral Science; A Study of Inorganic Nature. A Pupils' Exercise Book to accompany, by Miner H. Parrock, A. M., Head Teacher, Departments of Chemistry, Photo-Science, and Physiography, Technical High School, Providence R. I. Pages xiv+148. 13x18 cm. Cloth. 1911. 60 cents. Benj. H. Sanborn & Co., New York.

The book is the first to place the science found in minerals on a par with the science found in the organic kingdom, botany and zoölogy leading to biology.

While the author believes that minerals should be employed in the lower grades as a means of mental training to cultivate observation, discrimination, description, he believes also that in the high school minerals should be used in a broader sense as a first year science intermediate between the grammar school and the severer high school work of Physics and Chemistry and introductory to the higher inorganic sciences. This he accomplishes by grouping the topics in a logical sequence, dealing with

atoms, molecules and forces about the molecules that build the crystals and other mineral structures, and give the properties to inorganic matter. The author makes an important distinction between teaching minerals and teaching with minerals.

There are 40 pp. of Notes—physical, chemical, physiographic, economic, compiled from many sources. The book shows how to coördinate the subject with physiography, and with chemistry with numerous sketches of lessons in chemistry by minerals. It gives a list of minerals which may be used in qualitative analysis, and a complete analysis of a silicate by the "wet process." Finally it gives a chapter on the making of lantern slides for lecture work that is well worth the price of the book.

Who's Who in Science, edited by H. H. Stephenson, Chemist Royal Doulton Potteries, Lambeth, England. Pages xvi+572. 15x23 cm. Cloth. 1913. $2.00, net. J. and A. Churchill, 7 Great Marlborough Street, London.

The reviewer cannot do better than to reproduce his notice of this book on page 648 of the October issue, 1912, of this Journal. One valuable feature has been added in the 1913 edition which is a 58 page list of the scientific societies of the world, together with the address, president, secretary, date of foundation, number of members, dues and publications.

A book which has made a heroic attempt to tell "who's who" in science of men in all civilized countries. The author has done his work well in so far as it has been possible for him to go. Many names of prominent scientists do not appear, largely from the unwillingness of the person to comply with the request for information concerning himself. Banish this false modesty, the world has a right to know you and what you are doing. What a charming impression is made on one's mind, when hunting for information, where it should be found, to find that which you are after. Help the author of this work by transmitting to him a short account of yourself.

"Those branches of knowledge which lie on the border line between Science and the Humanities have not been included." Some of these are Economics, Education, Psychology, Sociology, etc. Those represented are as follows: Agriculture and Forestry, Anatomy, Anthropology, Astronomy and Meteorology, Botany, Chemistry, Engineering, Geology and Mineralogy, Mathematics, Mechanics, Pathology, and Pharmacology, Physiology, Zoölogy. There are, however, many names who have become leaders in the subjective sciences who at the same time have made brilliant success in the objective. In the biographical phase of the work more stress is put upon real work and worth than upon that side of science represented often in Ph.D. theses, hence but few degress are given, membership in recognized societies being given instead. All names, where possible, have been translated itno their English equivalent. The names of Journals are given in the language in which they are printed. To save time, labor, and space many abbreviations are used. A two-paged key to these is given at the beginning. Names of scientists who died in 1911 are printed. A valuable feature of the book is a list of 146 of the great universities of the world, together with the location, date of foundation, president or principal, registrar, and the name of the head professor of the sciences mentioned above. Each of the 6,000 (about) names is printed in bold face type followed in most cases with this information: position, positions held, where and when born, where educated, societies member of, books and articles written. There is a valuable classified index appended which gives the science in which the person is most interested and the country to which he belongs. It is avaluable book of reference.

C. H. S.

Genetics. An Introduction to the Study of Heredity, by Herbert E. Walter, Brown University. Pages xiv+272. 13x20 cm. 1913. Cloth. $1.50, net. Macmillan Company, New York.

This is an excellent book, one which will be of value to every intelligent person who is interested in the improvement of the all round physical and moral quality of the human race. It had its conception in a course of lectures given by the author at Brown University. These have been amplified and put into such shape that they can be used in the class room or in the library as a book of reference.

The author has, through considerable study and investigation, summarized a mass of information concerning the subject of heredity, arranging it in such a manner as to make it interesting reading to the general reader and seeker after knowledge. This book affords a splendid source from which the busy person can get quickly a good working knowledge of the subject of genetics. There are twelve chapters in which many phases of the subject are treated. There is bibliography and complete index. The book is well made. Type clear and large. The paper is unglossed thus avoiding needless light reflection. The book should have a large sale as it doubtless will have. C. H. S.

Physical Laboratory Guide by Frederick C. Reeve, Academy, Newark, N. J. Pages x+182. 13x19 cm. Cloth. 1912. American Book Company, New York.

A manual in which the author has made the explanations and directions clear and given enough so the pupil can proceed at once with his work without losing time. There are sixty-six typical experiments covering all the requirements for any college entrance board. Chapter X is devoted to a summary of the facts brought out in that part of the book devoted to experimental work. This is a good idea. There are XIX tables of physical comments which may be used in the work. A list of apparatus used in the book is given in Chapter XII. There is no index. The book is mechanically well made and printed in large type. C. H. S.

Heat, A Manual for Technical and Industrial Students, by J. A. Randall, Pratt Institute, Brooklyn. Pages xiv+331. 14x20 cm. 77 figures. Cloth. 1913. John Wiley & Sons, New York.

This is the first text written in this country which puts the gist of its emphasis on the application of the very fundamental principles of heat to the many commercial and engineering processes in which they are the controlling agents. It is written in a clear and understandable way. The reader with a good knowledge of secondary physics will have no difficulty in grasping all there is in the text. The mathematics used, have been reduced to a minimum. The subject matter is developed in a clear and logical manner. The author does not give a technical discussion of the selections of heat energy to its many applications but rather shows how this form of energy is used in a practical way in various steam power plants, gas plants, refrigeration, etc. The language used is well selected and in conformity to the best engineering practice. The problems are numerous and so selected to bring out in a practical way the principles studied. The drawings and half-tones are well selected and splendidly executed. They perform well their functions.

There are eleven chapters, each closing with a summary of the work discussed in it. There are five appendices, one on physical conshants which may be used in work with the text, one on barometer corrections and an important one on curve plotting. There is a good index. Mechanically the book is perfect. The type clear and set in a way to be pleasing to the reader. A splendid job of press work has been done on the book. It deserves a large sale, doubtless it will have such. It is just the book for technical schools and second year work in heat in high school. C. H. S.

Principles of Economic Zoölogy, by L. S. Daugherty, M. S., Ph. D. Professor of Zoölogy, State Normal School, Kirksville, Mo., and M. C. Daugherty, Kirksville, Mo. 301 illustrations. Pages vii + 410. 14 × 21 cm. 1912. Cloth, $2.00 net. Philadelphia and London: W. B. Saunders Company.

The reviewer was disappointed when he looked inside this book for the title "Economic Zoölogy" had led him to expect something different from what was actually found. There is no more space devoted to the economic phases of zoölogy in this book despite its title than one would expect to find in any modern up-to-date text. For example we find only eight lines given to the harmful relations of the housefly, two lines for the oxwarble, bare mention of the cattle tick and of various other animals of economic importance. The mosquito receives better treatment with about three pages devoted to the different species. On the whole the space devoted to the economic phases of animal study does not appear to justify the title. Indeed this appears to be the view of the author, for nothing is said in the preface to indicate that it was the intention to produce an economic zoölogy, rather we find a very lucid statement of what we actually find in the book, as follows: "The authors have long felt the need of one book in the hands of the student which would give not only the salient facts of structural zoölogy and the development of the various branches of animals, but also such facts of natural history—or the life and habits of animals—as to show the interrelations of structure, habit, and environment."

Judged by the author's statement as quoted above the book has much to commend it. There is an unusual amount of natural history of animals and the descriptions are concise and simple and arranged under convenient headings. The main feature to be commended, however, is the natural history which will make the book useful for normal school work and also for a high school text if the cost were not prohibitive for this use.

W. W.

College Zoölogy, by Robert W. Hegner, Ph. D., Assistant Professor of Zoölogy in the University of Michigan. Pages xxiv + 733. 14 × 19 cm. Figs. 553. 1912. $2.60, net. The MacMillian Company.

The first paragraph of the preface of this book gives a very succint and comprehensive statement of the purpose and scope of the book from the author's point of view, and I shall take the liberty of quoting it. "This book is intended to serve as a text for beginning students in colleges and universities, or for students who have already taken a course in general biology and wish to gain a more comprehensive view of the animal kingdom. It differs from many of the college textbooks of zoölogy now on the market in several important respects: (1) the animals and their organs are not only described but their functions are pointed out; (2) the animals described are in most cases native species; and (3) the relations of the animals to man are emphasized. Besides serving as a textbook it is believed that this book will be of interest to the general reader since it gives a bird's-eye view of the entire animal kingdom as we know it at the present time."

The above is a fair statement of the author's intentions and the general plan of the book, but to the reviewer it appears that the description of "animals and their organs" greatly overshadows the other phases. That the book gives a "bird's-eye view of the entire animal kingdom" is also impressed upon one as he glances through the formidable array upon succeeding pages. All facts and statements are set forth in a very terse way thus giving room for descriptions of a larger list of animals than one would ordinarily expect to find in a book of the size of this one.

One other feature should be mentioned. "Each phylum is introduced by a more or less complete account of the anatomy, physiology, and ecology of one, or in certain cases of two or more types." This plan has been quite consistently carried out. For the general reader or for the high school teacher this book together with the author's "Introduction to Zoölogy" issued not long ago will form a good reference set in zoölogy, the one supplementing the deficiencies of the other, used in this way the two books will be valuable additions to the libraries of secondary schoolteachers and no doubt also for college texts.

W. W.

Microscopy and the Microscopical Exan ination of Drugs by Charles E. Gabel, B. S., Ph. D., Microscopical Food and Drug Analyst, Iowa State Dairy and Food Commission. Size 20×14 cm. Pages 113. The Kenyon Co., Des Moines. 1912.

This book was prepared primarily for students of medicine and pharmacy. It consists of two parts: Part I. "Microscopy" and Part II. "The Microscopical Examination of Drugs." There follow tables, appendices on histological methods and drawings or cuts of apparatus, tissues and the optical properties of light.

The treatment of the subject is very elementary in scope and painstaking in statement. It would be a very dull student who could not master the contents of the book. W. W.

Agricultural Education in the Public Schools, by Benjamin Marshall Davis. Pages vii+163. 15 x 23 cm. 1912. University of Chicago Press.

The desirability of agricultural education has long been recognized. but the present interest in all forms of vocational training has given new strength to the forces working toward the establishment of a system of general agricultural education. Professor Davis has in this volume given an account of the development and work of all the agencies which are doing significant work in extending and developing education of this type. He has in this way aided materially in defining the problem as well as to open the way for a proper correlation of the various agencies which are at work in this field.

Students who expect to teach agriculture and science teachers who begin to feel the necessity of correlating their work with agriculture will find this book an excellent introduction. An annotated bibliography of 202 titles affords an open highway into the literature of the subject. W. L. E.

The Soil Solution, by Frank K. Cameron. Pages v+136. 14 x 23 cm. $1.25. 1911. Chemical Publishing Co., Easton, Pa.

The theory of plant nutrition which is popularly held assumes that a principal function of the soil is to supply the plant with mineral nutrients, that these mineral nutrients are readily depleted by continued cropping, and that the importance of fertilizers lies in the quantitative replacement of these nutrients by their use. With this view Cameron does not agree, and his statement may be taken as representing the views of the Bureau of Soils in the controversy that has arisen.

Cameron finds all investigations of the concentration of phosphorus, calcium and potassium in the soil solution (soil water) indicate a constant quantity for each of these elements regardless of the "good" or "poor" character of the soil. It is also found that the normal concentration of these substances in the soil is the optimum concentration for plant growth, and therefore no addition of "plant food" to the soil is needed or can be effective as a nutrient.

It is also found that the so-called nutrient salts are often ineffective when they would appear most necessary, while other chemicals which contain neither phosphorus, calcium or potassium do produce markedly increased crops.

It follows from these considerations that our present practice in the application of fertilizers whereby we attempt to replace the amount of each element that has been withdrawn by the crop, is empirical rather than rational. Before we shall be able to rationalize our practice we must learn the true character of the action of the fertilizer. This probably consists in action upon the various chemical, physical and biological factors of the soil rather than in any supply of material to the plant directly. Most soils contain a great many organic compounds which have arisen as excretions from plants or as products of decay and certain of these are detrimental to plant growth. The common fertilizing substances appear to inhibit this unfavorable action and thus negatively assist the growth of plants. W. L. E.